AEROWINX®

OPERATIONS MANUAL

Version 10.1.7

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This book is part of the Precision Simulator 10 software, distributed on DVD.

Manufactured in the European Union.

Visit Aerowinx at

aerowinx.com

Precision Simulator 10 is the successor to the version-1 series that I developed between 1995 and 2003. The version-10 project began in June 2008; the plan was to convert the version-1 Pascal code to Java code, enhance the graphics, add some new features, and release the product in 2010. However, this plan was soon discarded, and the release date was, from then on, undetermined: instead of converting old code, I decided to keep rewriting *everything* from scratch, and to implement many more features than originally planned. In 2013, the implementation was completed; the beta test and the work on this book could start. In June 2014, the product was finished.

For their great support over the past years, by testing, proofreading, or by writing add-ons, I want to thank the team; in alphabetical order: Avi Adin (special thanks!), Jon Boe, Michael Bradbury, Farrokh Chothia, Will Cronenwett, Martin Erdelen, John Golin, Jeroen Hoppenbrouwers, Torrence V. Johnson, Rodney Redwin, Garry Richards, Matthew Sheil, Pierre Theillere, Brent Vernon, and—most importantly—John H. Watson.

I also want to thank all the kind people who have motivated me by contributions on the Aerowinx forum.

And I am grateful to Doug Snow, Marc Brodbeck, Joe Corrigan, Stephen Bell, Miriam Larinkoski-Erdelen, Isabelle Sheil, Peter Cos, and John Davis.

Numerous voice audio files have been carried over from the previous versions. So my thanks are again due to the air traffic controllers Charlotte Long (recorded by Paul Story, thank you!), Peter Franklin, Michel Jobé; and to the then 744 pilots Mel J. Ott, Sarah Eustance, Roland Peeters, and Sean Trestrail.

Hardy Heinlin
June 2014

This is now the second edition of the version-10 operations manual. Three years have passed since the release of Precision Simulator 10.0.0; many more kind individuals from various engineering and aviation backgrounds have since joined the simulator's user community and contributed with further system tests and clever suggestions.

I am particularly grateful to the add-on designers and interface developers Nico Kaan, Gary Oliver, Mark Barnes, Michael Benson, Craig Phillips, Balthasar Indermühle, Jean-Philippe Lepine, Ian Hopper, Paolo Sotgiu, Vitomir Štokić, Robert Kock, along with Felix, Bernd, and all the constructive thinkers on the 744 forum.

For their attentive technical support from the pilot's point of view and for making helpful video tutorials for the community I especially want to thank Peter Ward and Jon Del Turco; moreover, I am grateful to all pilots on the forum who have helped answering countless difficult questions.

I am very thankful to Brian Cowell for his comprehensive "Getting Started" tutorials which have been of great help to new users. Likewise, I thank Adrien Amiot for compiling a step-by-step standard operations guide.

And I really appreciate the additional voice recordings created by Sylvain Coolsaet and Ivo de Colfmaker.

Also, for their ongoing support and further add-ons, special thanks are again due to the productive gentlemen mentioned on the previous page!

Hardy Heinlin
May 2017

In memory of

Jörg Löhnig Mel J. Ott

Shiv Mathur

Contents:

Simulator Handling

Introduction:

Precision Simulator models the combi, freighter, passenger, ER-freighter, and ER-passenger variants of the B744 series. In addition, several airline options can be selected re airframe, avionic equipment, and system logic. In this book, every aircraft specific, user selectable option is marked with this **green arrow**:

A

Precision Simulator is a complete, stand-alone, flight simulation software package. It integrates type-specific engine performance data and a comprehensive, fine-tuned **aerodynamics model** for inflight and ground operations, along with a ground roll model simulating variable slopes and surface conditions, skid, gear faults, and so on.

A dynamic, global **atmosphere model** generates usual and unusual weather. This includes hazardous weather phenomena like volcanic ash or jet stream induced CAT (a season dependent, world-wide jet stream system is embedded), as well as finer nuances like temperature related, non-ISA pressure lapse rates—or pressure drifts smoothly modulated by real-world weather data from the Internet, for example.

The **flying area** is the entire world. The database contains all airports whose longest runway is at least 1400 m (4600 ft) long. The out-of-the-windshield view is simplified in order to provide maximum computer power to the aircraft systems, yet the view is sufficient to support instrument flight training with visual cues such as traffic, weather effects, runways, and other objects.

Precision Simulator models numerous **avionic components** and mechanical parts—like valves, motors, pumps—in the invisible background; the output of these models becomes visible through flight deck indications or by the behavior of the aircraft. The components also interact with each other, causing very complicated, interdependent series of consequences. This book, being limited to circa 600 pages, can only describe the most important aspects of the aircraft systems; the simulator actually includes many more features. If you have questions that are not discussed in this book, please refer to the 744 forum in the Internet at *aerowinx.com*.

To add communicational contexts to training scenarios, **human simulations** interact as ATC (voice and CPDLC), cabin crew (interphone system demo), ground crew (towing), air traffic (TCAS), PNF (checklists, calls, silent tasks), and ATIS.

With its flexible graphic layout system and network capability, Precision Simulator can serve **various purposes**: run it on a single computer and use it as an FMS CBT with split screen layout, or choose a PFD-centered layout, ergonomic for instrument training; or connect multiple computers and monitors to set up a large, all-real-size flight deck environment, possibly with touchscreens; or integrate the simulator's instrument displays in third-party hardware, and interface the simulator's system data with external switches and lights; feed a third-party motion platform driver or scenery generator; or connect two instances of the simulator via Internet and run a multi-crew session; or network the simulator for use as a virtual test aircraft in scientific real-time experiments, and so forth.

System Requirements:

+ **Java version 1.6 or higher**. If Java is not already installed on your computer, or if it needs to be updated, it can be downloaded free of charge from *java.com*.
+ **Apple OS X** or **Microsoft Windows** or **Linux** operating system.
+ A **monitor with at least 800 x 800 pixels.** Undersized monitors can be used as well—for example, to display small flight deck sections on networked monitors—, but the *instructor screen* will then be cropped, and should then be displayed on a second, suitable monitor.
+ **Dual-core** or **multi-core microprocessor**, running at **2.5 GHz or higher.**
+ **4 GB RAM or more.**
+ **3 GB free hard disk space.**
+ A **keyboard**, ideally one that includes a numeric keypad.
+ A **mouse** or **touch screen** or any similar pointing device.
+ **Access to a DVD drive** is required for the initial installation.

Optional

- USB yokes, sticks, pedals, throttles, buttons, and other USB inputs.
- Add-on software & hardware compatible with the Aerowinx TCP/IP network.

Java utilizes *hardware acceleration* for the graphics. Hence, the frame rates in the simulator are very high, typically ranging from 30 to 70 fps.

End User License Agreement:

This text is printed on the DVD box.

END USER LICENSE AGREEMENT

This copy of Aerowinx Precision Simulator (herein called "Software") is not sold, it is licensed. The Software includes the operations manual, the file *Aerowinx.jar*, and the contents of the folders *Navigation* and *Visuals*. The Software is protected by copyright laws and treaties, and is the intellectual property of Hardy Heinlin, Germany. The rights of the licensee (herein "you") regarding the Software are subject to the terms and conditions of this end user license agreement (herein "Agreement"). You accept the Agreement by installing, using, or copying the Software. The Agreement authorizes you to install up to FOUR copies of the Software within one flight deck mockup or within one classroom of an officially registered academy or airline. You and your visitors may use these copies within your mockup or classroom. Additionally, you are allowed to make one backup copy which may only be used for the reinstallation of the Software. You may not decompile or otherwise try to obtain the source code of the Software. You are not authorized to sell the Software, or otherwise transfer your rights under this Agreement.

Installing the Simulator:

For the **initial** installation, insert the Aerowinx DVD into the DVD drive that is connected to your computer, and double-click the file *Installer.jar* located on that DVD. Then follow the on-screen instructions.

If you like to install **another copy** within a local computer network, copy the installed *Aerowinx* folder from the main computer directly through the network to the target computer to a folder of your choice. The operating systems of the networked computers are not required to be identical; for example, you can copy the *Aerowinx* folder from a Mac to a Windows computer.

If you want to run multiple networked simulator instances **on one computer**, it is not necessary to make a copy for every instance; all instances can be started from one and the same *Aerowinx* folder on that computer.

Regarding **your rights** on installing multiple copies, refer to the end user license agreement displayed on the previous page and on the DVD box.

Uninstalling the Simulator:

When installing Precision Simulator, the settings of the computer's operating system will not be changed, and there will be no simulator specific files outside the *Aerowinx* folder. Therefore, when you wish to remove the simulator from a computer, just delete the respective *Aerowinx* folder.

Starting the Simulator:

Open the *Aerowinx* folder (if you have installed it on the desktop, open it by double-clicking the *Aerowinx* folder on the desktop). To start the simulator, double-click the file *AerowinxStart.jar* located in that folder.

If double-clicking any *jar* file does not start Java, although Java is installed, an application other than Java may be assigned to all *jar* files. Should this be the case (very rare), this is the solution:

In OS X, right-click *AerowinxStart.jar*, click **“Open With”**, then **“Jar Launcher”**.

In Windows, right-click *AerowinxStart.jar*, click **“Open With...”**, then **“Java”**.

In Linux, right-click *AerowinxStart.jar*, click **“Open with Other Application...”**, then double-click **“Java”**.

Making an Alias in OS X:

Drag the file *AerowinxStart.jar* with the mouse to the desktop while pressing the ALT and CMD keys. This creates an alias on the desktop. Double-clicking this alias has the same effect as double-clicking *AerowinxStart.jar*.

Creating a Shortcut in Windows:

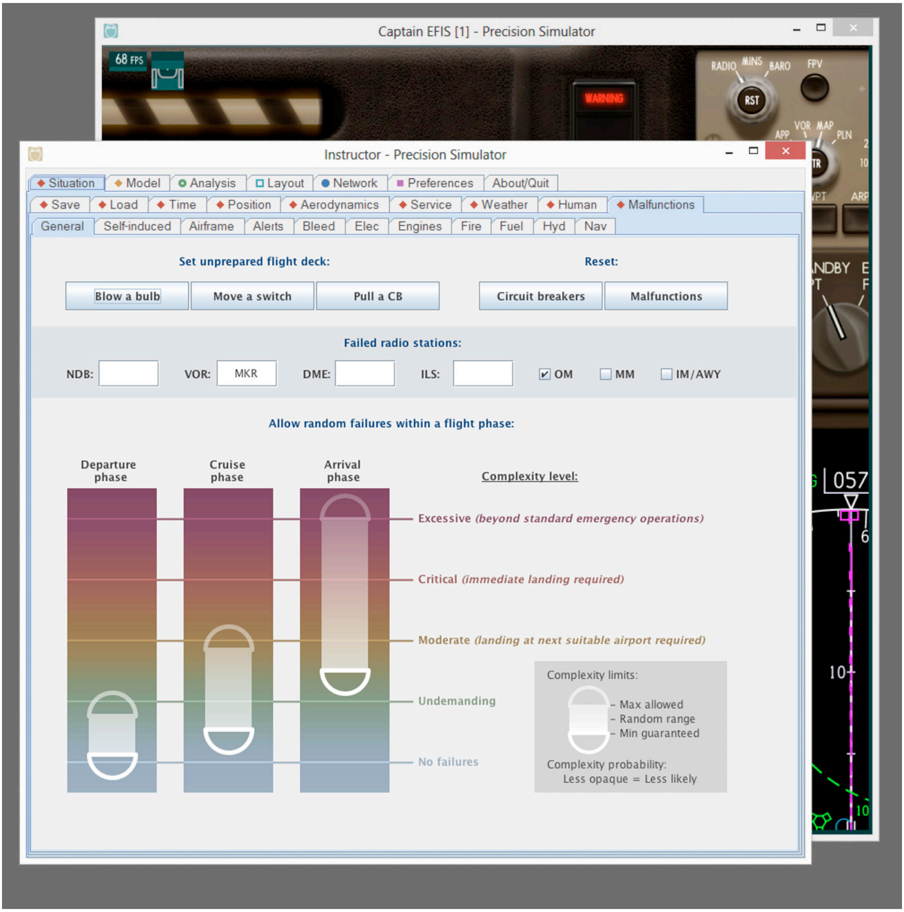
Right-click the mouse on the file *AerowinxStart.jar*, then click **“Send to”** and **“Desktop (create shortcut)”**. This creates a shortcut on the desktop. Double-clicking this shortcut has the same effect as double-clicking *AerowinxStart.jar*.

Making a Link in Linux:

Right-click the mouse on the file *AerowinxStart.jar* and click **“Make link”**.
This creates a link icon in the *Aerowinx* folder. Drag this icon to the desktop.
Double-clicking this icon has the same effect as double-clicking *AerowinxStart.jar*.

If desired, the above methods in OS X, Windows, or Linux, may also be applied to the files *AerowinxNetStart.jar* and *Aerowinx Operations Manual.pdf*.

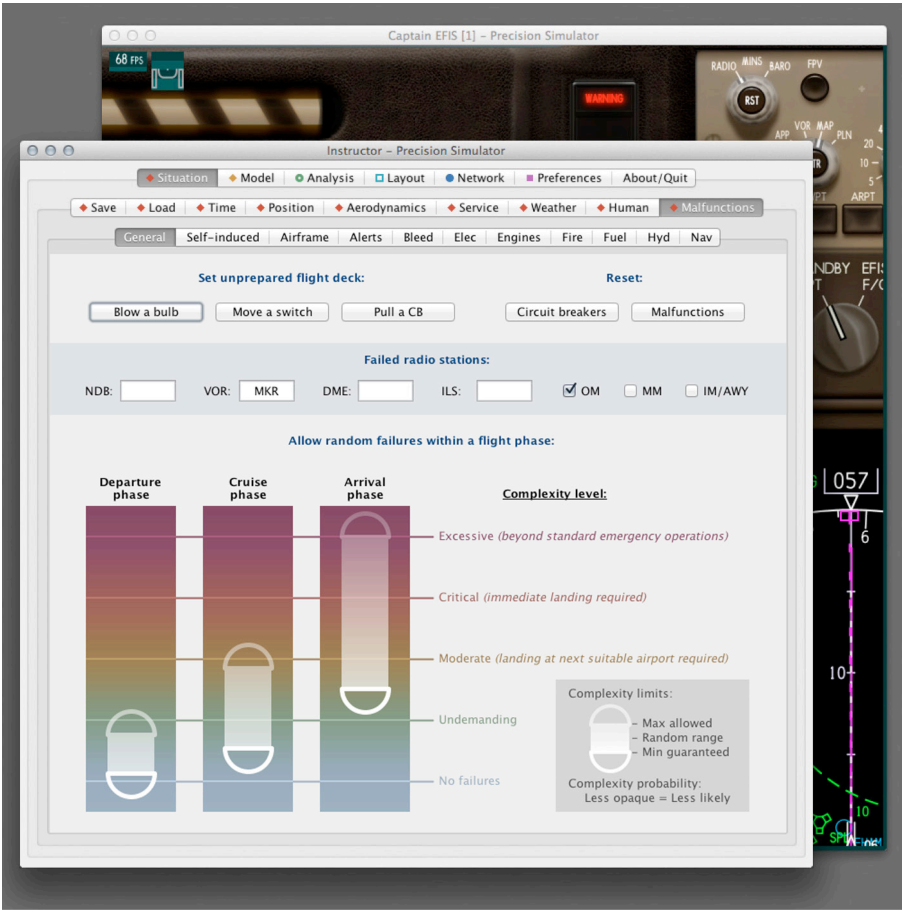
Java Look & Feel:



The simulator basically provides two frames: the instructor frame (Instructor) and the flight deck frame (with user defined frame titles). The look & feel of the frame decorations, and of some objects on the Instructor, depend on the operating system in use. The screenshot above shows the simulator running on Windows 8 which uses the *standard* Java look & feel.

(continued next page)

Java Look & Feel: *(continued)*



This screenshot shows the simulator running with Apple's Java look & feel. The most significant difference between this and the *standard* Java look & feel is the design of the tabs (tabs are the pushbuttons labeled with *Situation*, *Model*, *Analysis*, and so on). In OS X, the tab bars are positioned symmetrically. However, the order of the labels from left to right is identical in all versions.

User Files – Overview:

User files that can be saved and loaded through the Instructor

Situation files store situational and aircraft model variables. These are variables that are also transmitted across the simulator's main network when connected.

Model files store aircraft model variables only. Loading such a file will load an aircraft model only, and will not change other situational data, unless it is forced to do so; for example, if the loaded aircraft's fuel tank capacity is smaller than the fuel quantity currently on board, the quantity will be reduced accordingly.

Layout files store user defined zoom, pan, and subframe divider settings of the flight deck frame. Each layout file stores nine layouts; the keys 1 to 9 on the numeric keypad, for example, will switch between the nine layouts.

Preferences files store computer specific data, such as the preferred USB and audio selections, mouse functions, and so on.

Other user files

Route files, located in the *Routes* folder, store FMC company routes. They can be stored through the Instructor, and loaded in the simulated FMC which accepts two file formats: the *Aerowinx* format, and the *PFPX* format by *flightsimsoft.com*.

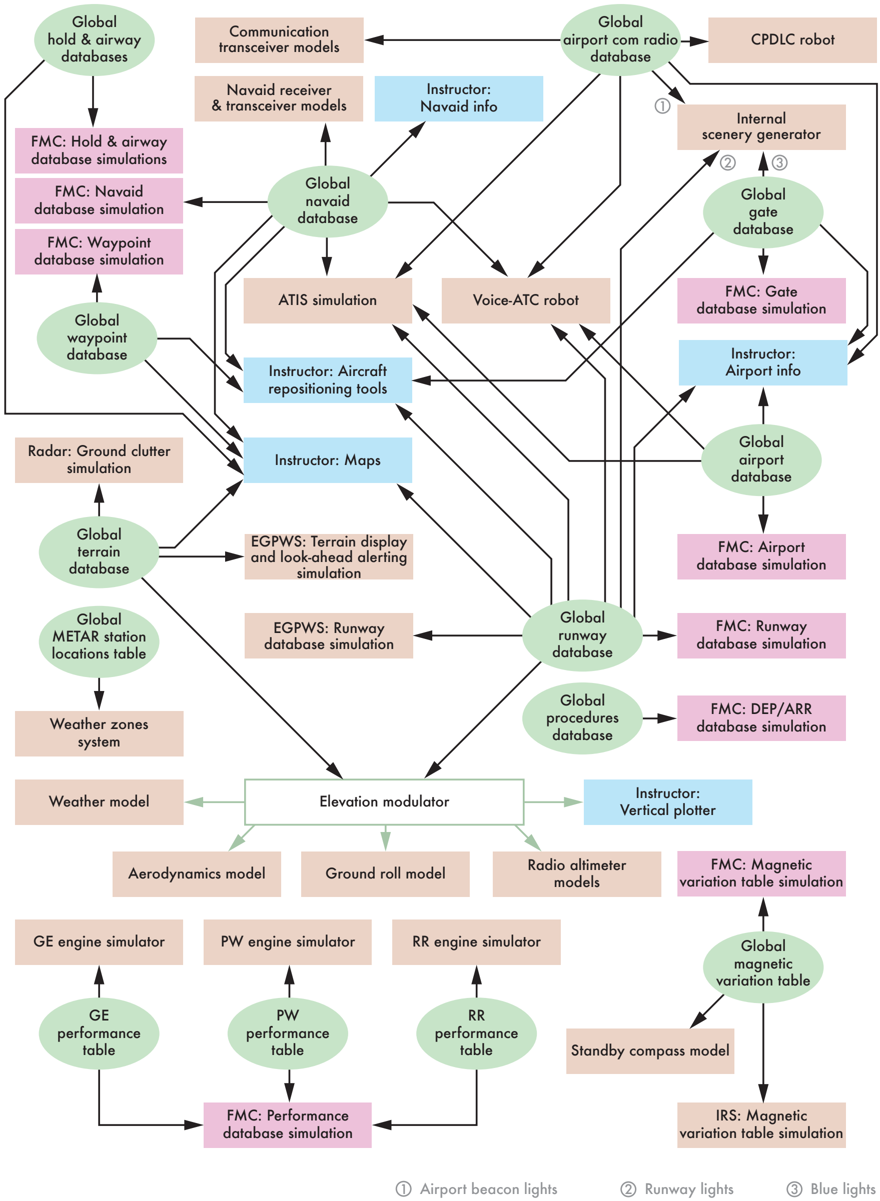
A track plot file, located in the *Logs* folder, stores the aircraft lateral track of the past 20 hours. The plotter pauses when the aircraft is stationary. The data can be completely erased on the Instructor.

METAR files, located in the *Weather* folder, store world-wide METAR data downloaded from the Internet. During every simulator start, all METAR files stored in this folder, except for the latest two files, will be deleted.

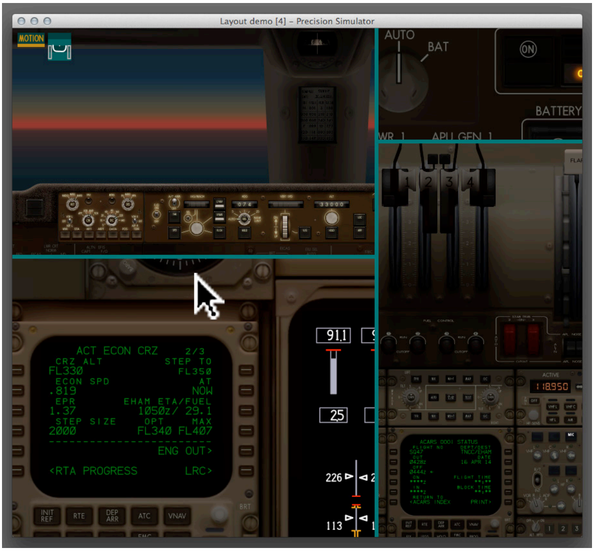
Databases:

The simulator contains some primary databases, each feeding one or multiple simulator components. The next page illustrates which database feeds which component. The green ovals indicate the actual, physical (primary) databases. On the real aircraft, each component—like the FMC or EGPWS—uses its own individual database; whereas the components in the simulator just *simulate* their individual databases because, in fact, they are all supplied by the same primary database, and just hide certain variables (hiding the NDB frequencies in the FMC database simulation, for example, because the real FMC does not store these frequencies).

Database Hubs:



Mouse – How to Drag a Subframe Divider:



Step 1

The flight deck frame may be divided into two, three, or four subframes. Divider lines are displayed in dark cyan. To resize the subframes, place the mouse on a divider. The mouse pointer will change to a special cursor as illustrated in step 2 (the shape of the cursor is operating system dependent).

Step 2

Press and hold the left mouse button—all dividers now appear in light cyan—, then drag the divider to the desired position.

(continued next page)

Mouse – How to Drag a Subframe Divider: *(continued)*

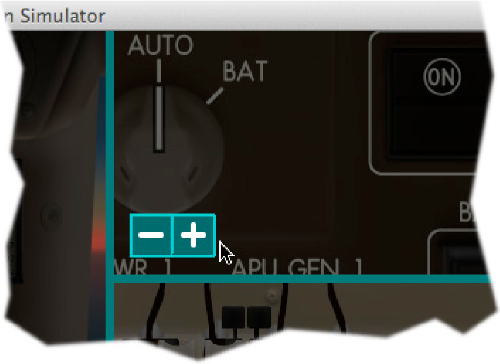
Dividers at the outer edge

Dividers are never completely outside the flight deck frame. When dragged to the upper, lower, left, or right outer edge, a fraction of the divider remains visible to allow the mouse to grab it and drag it back in. When grabbing a divider at the outer edge, be sure to grab the *divider* and not the edge of the flight deck frame, otherwise the flight deck frame will be dragged. To avoid this, keep the mouse inside the flight deck frame.

Mouse – How to Pan a Subframe:

While holding the **right mouse button**, or while holding the ALT key on the keyboard, move the mouse within the respective subframe.

Mouse – How to Zoom a Subframe:



When the mouse is parked in the lower left corner of a subframe, a minus and a plus switch appear. Clicking and holding such a switch with the **left mouse button** zooms the respective subframe out or in. Additionally holding the **right mouse button** increases the zoom speed.

A subframe can also be zoomed using the **mouse wheel**: place the mouse within the respective subframe and rotate the mouse wheel while holding the right mouse button, or while holding the ALT key on the keyboard.

Zoom focal point

In the lower left, lower right, and upper right subframes the zoom focal point is always located in the middle of the subframe; that is, when zooming in or out, objects in the middle will stay in the middle.

In the *upper left* subframe, when zooming with the *mouse wheel*, the zoom focal point is located at the mouse cursor. Otherwise, when using the minus or plus switch, the focal point is in the middle of the subframe.

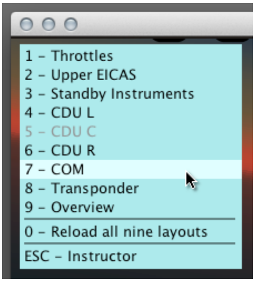
Mouse – How to Display the Frame Data:

When the mouse cursor is placed on a divider and the left mouse button is pressed, the **frame title** indicates the following data from left to right: the pixel coordinates of the flight deck frame's upper left corner on the desktop; the flight deck frame size; the zoom factors of the upper left, lower left, upper right, and lower right subframes. The zoom factors are also displayed during zooming.

On monitors with a resolution of 96 pixels per inch, zoom 1.0 will show flight deck objects approximately in real-world size. Maximum zoom is 3.0.

Frame settings can be stored in layout files on **Instructor > Layout**.

Mouse – Flight Deck Controls in General:



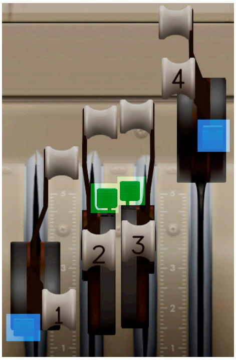
When the mouse hovers over the upper left corner of the flight deck frame, a menu appears; you may click one of the nine layouts, or reload the last loaded layout file, or show the Instructor. This menu is intended for use as a backup control when a keyboard is currently not available.

The simulator contains many different mouse cursors; they appear when the mouse is placed in areas where special mouse functions are enabled. With this visual support, the mouse functions are quite self-explanatory. The following pages provide some additional hints.

Note that toggle switches on the flight deck can be toggled up and down by clicking them with the left mouse button, or—alternately—by turning the mouse wheel up or down.

Optical illusions: When a rotary selector turns very quickly, it sometimes looks as if it turned oppositely to the commanded direction. This is an unavoidable strobe effect in the computer graphics. The selector actually turns into the correct direction.

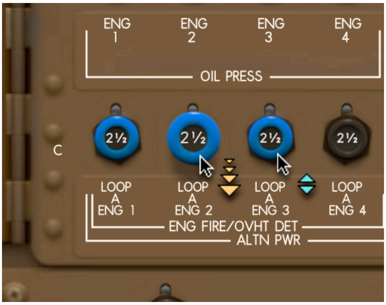
Mouse – How to Click the Autothrottle Switches:



As the autothrottle switches move with the thrust levers, the respective mouse areas move with them as well. On the picture to the left, the areas illustrated in blue are the click areas for the autothrottle disconnect switches, and those in green are for the TO/GA switches. For more details on autothrottle functions, refer to chapter **Automatic Flight**.

(These switches, and other controls, can also be actuated by the keyboard, by USB inputs, or by network injections.)

Mouse – How to Actuate a Circuit Breaker:



To pull or push a circuit breaker (CB), left-click with the mouse on the respective CB. Pulled CBs appear slightly larger, and have a longer shadow. To help distinguish a pulled CB from a pushed one, four orange triangles are attached to the mouse cursor when hovering over a pulled CB. For more details on CBs, refer to chapter **Electrical**.

Mouse – How to Move the Yokes and Throttles:

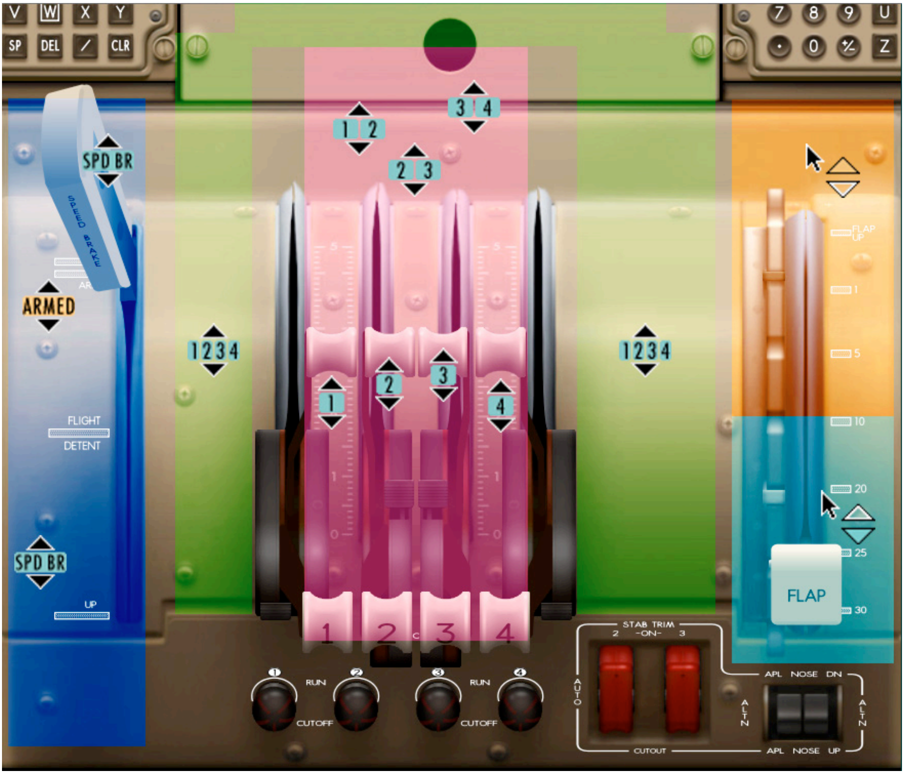
When the mouse is placed in the red zones—that is, on the windshields, PFDs, NDs, or seat areas—, the *yoke* cursor appears, allowing the mouse to drag the aileron control wheel left and right, and the elevator stick forward and aft (up and down). When the mouse button is released, all controls are centered.

The *yoke* cursor also enables the **mouse wheel** to actuate the yoke stabilizer trim switches. When in the red zones, avoid moving the mouse wheel while the autopilot is engaged; stabilizer trimming may disengage the autopilot.

On the ground, when the groundspeed is above zero and below 40 kt, the *yoke* cursor changes to a *tiller* cursor: drag and hold the cursor left or right to rotate the gear steering tiller. Release the mouse button to center the tiller.

Within the green zone, the mouse is enabled to drag all four thrust levers simultaneously—the mouse wheel may be used as well.

Mouse – How to Handle the Thrust Lever Quadrant:



The colors in this picture illustrate special mouse areas:

Blue: Allows the speed brake lever to be dragged, or to be moved by the mouse wheel. When the lever is in the armed position, the mouse cursor indicates ARMED. (Refer to chapter **Flight Controls**).

Green: Allows all four thrust levers to be dragged, or to be moved by the mouse wheel.

Magenta: In this area, the mouse can drag a single thrust lever, or a thrust lever pair. Relevant for the lever selection is just the *horizontal* mouse position; for example, when placed between the tracks of levers 1 and 2 (the *vertical* position does not matter), the mouse can drag levers 1 and 2. The mouse wheel may be used too.

Orange: In this area, clicking the left mouse button moves the flap lever one step towards UP. The mouse wheel may be used too. The gates at flaps 1 and 20 will stop the lever when a position is commanded past the gate before the lever has reached the gate.

Cyan: Same function as in the *orange* area, but moving the flap lever downward.

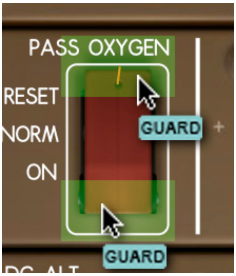
Mouse – How to Move the Reverser Levers:

The reverser levers can be dragged like the forward thrust levers as described on the previous page, but a reverser lever can only be moved when the associated forward thrust lever is set to idle. During landing, proceed as follows:

1. Drag the forward thrust levers to idle.
2. **Release the mouse button.**
3. After touchdown, drag the reverser levers towards the bottom of the screen until the levers are snapped into the idle reverse position. This will cause the reversers to deploy while the thrust remains at idle.
4. **Release the mouse button.**
5. Drag the reverser levers further towards the bottom of the screen until the levers stop at the maximum reverse thrust limit. This step is only possible when the reversers are sufficiently deployed; the deployment takes circa 2 seconds.
6. When the airspeed decreases through 80 kt, drag the reverser levers towards the top of the screen until they stop at the idle position. This will cause the engines to spool down to idle thrust.
7. **Release the mouse button.**
8. When the airspeed decreases through 60 kt, drag the reverser levers again towards the top of the screen until they snap into the stowed position. This will cause the reversers to retract.
9. **Release the mouse button.**

(The reverser levers, and other controls, can also be moved by the keyboard, by USB inputs, or by network injections.)

Mouse – How to Move a Switchguard:



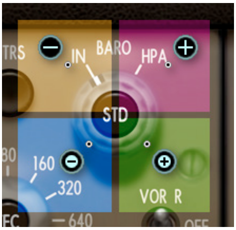
When the mouse is placed within the upper or lower part of the switch—here illustrated in green—the mouse cursor changes to a *guard* cursor, indicating that the left mouse button is now enabled to open and close the switchguard.

Mouse – How to Turn a Single Rotary Selector:

When the mouse is placed inside the left or right half—here illustrated in blue and green—the mouse cursor changes to a *rotation* cursor. When this cursor is shown, clicking or holding the left mouse button will rotate the knob into the indicated direction. When the right mouse button is held additionally, the rotation speed will be higher.

When a *rotation* cursor is shown, the mouse wheel is enabled as well. On the left half, wheel-down actions turn the knob anti-clockwise, on the right half clockwise.

Mouse – How to Turn a Dual Rotary Selector:



Rotary selectors which consist of an outer and an inner ring are surrounded by four quadrants—here illustrated in four colors. When the mouse enters a quadrant, the cursor changes to a large or a small *minus* or *plus* cursor. Clicking or holding the left mouse button will then do the following:

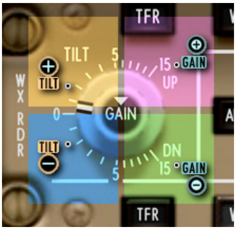
Large minus (orange):	Turns outer knob anti-clockwise.
Large plus (magenta):	Turns outer knob clockwise.
Small minus (blue):	Turns inner knob anti-clockwise.
Small plus (green):	Turns inner knob clockwise.

In other words, the upper quadrants refer to the outer ring, the lower quadrants to the inner ring.

When the right mouse button is held additionally, the rotation speed will be higher.

When such a cursor is shown, the mouse wheel is enabled as well. On the left side, wheel-down actions turn the rings anti-clockwise, on the right side clockwise.

Mouse – How to Turn the Tilt and Gain Selectors:



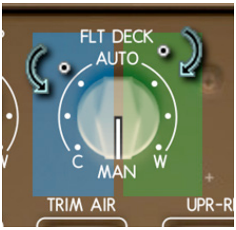
Rotary selectors on the weather radar control panel (refer to chapter **Navigation Systems**) are, similar to other dual selectors, surrounded by four quadrants—here again illustrated in four colors. But the layout is slightly different. When the mouse enters a quadrant, the cursor changes to a *tilt* or *gain* cursor. Clicking or holding the left mouse button will then do the following:

Plus tilt (orange):	Turns the tilt knob clockwise.
Plus gain (magenta):	Turns the gain knob clockwise.
Minus tilt (blue):	Turns the tilt knob anti-clockwise.
Minus gain (green):	Turns the gain knob anti-clockwise.

For the tilt, when the right mouse button is held additionally, the rotation speed will be higher. The gain knob, however, is a rotary switch (with 10 positions), therefore the gain knob can only be clicked, and not accelerated.

When a *tilt* or *gain* cursor is shown, the mouse wheel is enabled as well. On the left side, wheel-down actions turn the knobs anti-clockwise, on the right side clockwise.

Mouse – How to Turn a Temperature Selector:



Some selectors on the air conditioning panel (refer to chapter **Air Systems**) can be rotated like a normal rotary selector, but they also provide a switch function when the selector is snapped into the 6 o'clock position. In this position, the selector can be held against the C or W position ("colder" or "warmer"):

To prepare the C selection, place the mouse on the right half (the *clockwise rotation* cursor will appear).

To prepare the W selection, place the mouse on the left half (the *anti-clockwise rotation* cursor will appear).

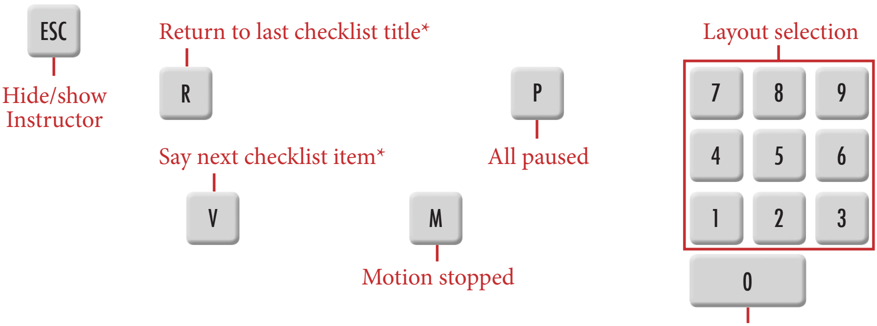
Then hold the left mouse button for circa 1 second; if it is held for more than 2 seconds, the selector will jump further upward and enter the AUTO range.

When the right mouse button is pushed as well, the selector will jump upward promptly without the 2-second delay.

By repeatedly holding and releasing the left mouse button in 1-second intervals, the temperature will change successively.

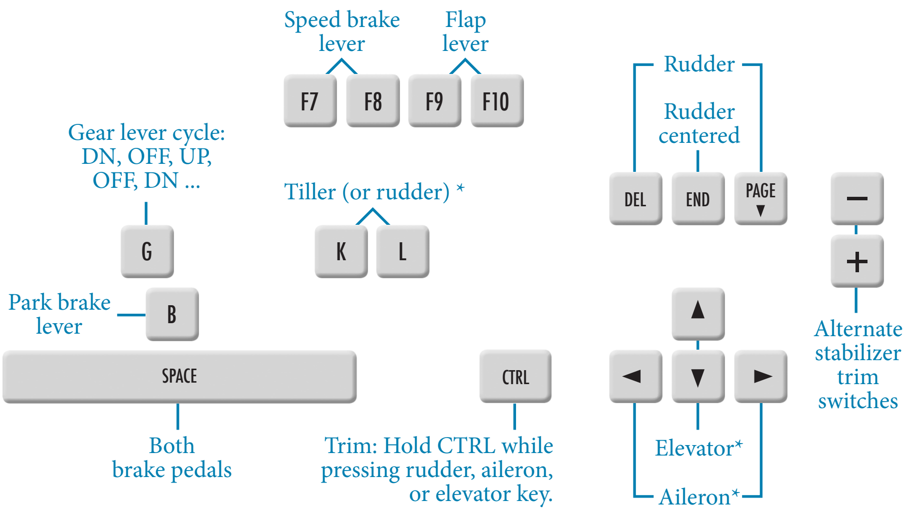
The mouse wheel is disabled for this switch function.

Keyboard – Essential Functions:



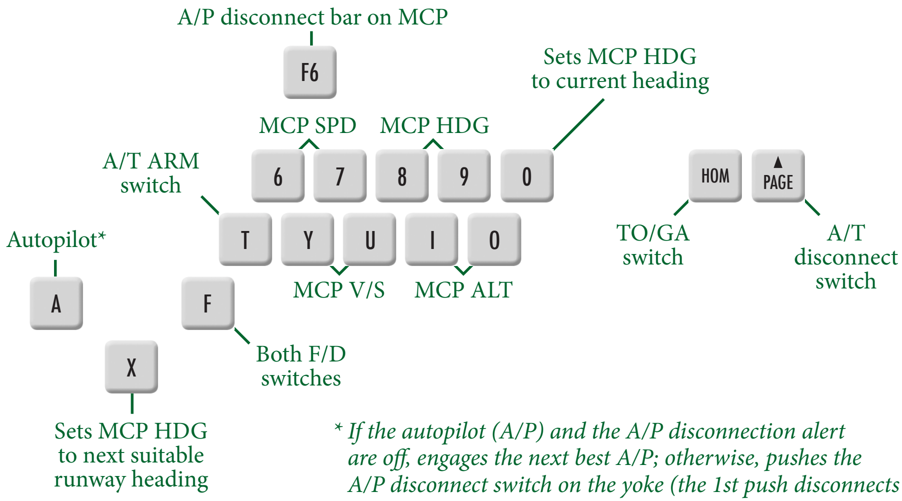
** Cycles infinitely through all checklists (when the last item of a flight is reached, continues at the first item, or vice versa).*

Keyboard – Ground & Flight Controls:



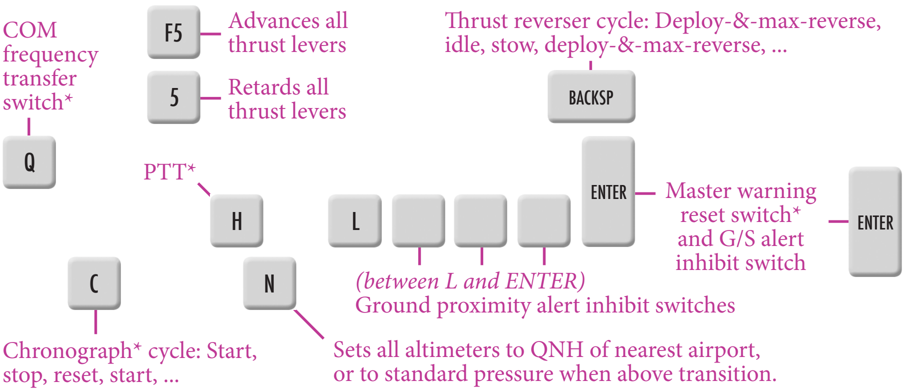
** Any deflection will self-center slowly when the keys are released. To center it promptly, hit the opposite key.*
The steering tiller keys are enabled when the groundspeed is above zero and below 40 kt; when the groundspeed is above 50 kt, the K and L keys move the rudder pedals, and the pedals will only center when K and L are pressed at the same time.

Keyboard – Important Autoflight Functions:



** If the autopilot (A/P) and the A/P disconnection alert are off, engages the next best A/P; otherwise, pushes the A/P disconnect switch on the yoke (the 1st push disconnects the A/P, the 2nd push silences the disconnection alert).*

Keyboard – Other Useful Functions:



** On the captain's side when the first officer is the PNF, else vice versa.*
Note that the COM frequency transfer is inhibited for 1 second after the last transfer.

Keyboard – Connection to a CDU:

There are three CDUs (CDU L, R, and C; for details, refer to chapter **FMS**).

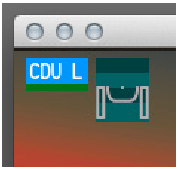
The keyboard can be connected to a CDU as follows:

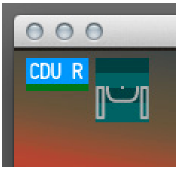
- To connect it to CDU L, hit the left Shift key (do not hold the key).
- To connect it to CDU R, hit the right Shift key (do not hold the key).
- To connect it to CDU C, hold a Shift key and a Ctrl key simultaneously, then release the Shift key, then release the Ctrl key.

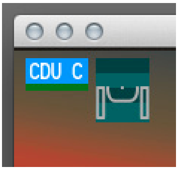
To connect another CDU, first disconnect the connected CDU:

- To disconnect a CDU, hit a Shift key.

When the keyboard is connected to a CDU, the upper left corner of the flight deck frame indicates the respective CDU tag (if info tags are enabled on **Instructor** > **Preferences** > **Basics**):







When the keyboard is connected to a CDU, the keys provide the following functions:

F1 ... F6	Right line select keys
1 ... 6	Left line select keys
Alt + Q	INIT REF
Alt + W	RTE
Alt + E	DEP ARR
Alt + R	ATC
Alt + T	VNAV
Alt + A	FIX
Alt + S	LEGS
Alt + D	HOLD
Alt + F	FMC COMM
Alt + G	PROG
A ... Z	A ... Z
0 ... 9	*(numeric pad)* 0 ... 9

Backsp	CLR
Home	MENU
Page up	NAV RAD
Del	DEL
End	PREV PAGE
Page dn	NEXT PAGE
Enter	EXEC
Space	SP
Divide	*(numeric pad)* Slash
Minus	*(numeric pad)* +/–
Plus	*(numeric pad)* +/–
Period	*(numeric pad)* Period

Keyboard – Summary:

When not connected to a CDU, the keys provide the following functions (those in brown font refer to the captain's side when the first officer is the PNF, else to the first officer's side):

Esc	Shows or hides Instructor *(also works when a CDU is connected)*
Ctrl+Alt+Esc	When hidden, shows Instructor and resets it to default size
F1	Quickly advances thrust lever 1
F2	Quickly advances thrust lever 2
F3	Quickly advances thrust lever 3
F4	Quickly advances thrust lever 4
F5	Quickly advances all thrust levers
F6	A/P disengage bar on MCP
F7	Moves speed brake lever forward
F8	Moves speed brake lever aft
F9	Moves flap lever forward
F10	Moves flap lever aft
F11	Initiates or disables virtual pilot's manual take-off control
1	Quickly retards thrust lever 1
2	Quickly retards thrust lever 2
3	Quickly retards thrust lever 3
4	Quickly retards thrust lever 4
5	Quickly retards all thrust levers
6	Turns SPD selector by –1 unit
7	Turns SPD selector by +1 unit
8	Turns HDG selector by –1°
9	Turns HDG selector by +1°
0	Sets MCP HDG to current heading
Backspace	Cycles reversers: Deploy-&-max-reverse, idle, stow, ...
Home	TO/GA switch
PgUp	A/T disconnect switch
Q	COM frequency transfer switch
W	Turns outer COM standby frequency selector up
E	Turns inner COM standby frequency selector up
R	Causes PNF to say last checklist title
T	A/T ARM switch
Y	Turns V/S selector by –100 fpm
U	Turns V/S selector by +100 fpm
I	Turns ALT selector by –100 ft
O	Turns ALT selector by +100 ft
P	Pauses/unpauses entire simulation, including flight deck controls.

(continued next page)

Keyboard – Summary: *(continued)*

A	Cycles: Autopilot engaged, disconnected, alert reset, ...
S	Turns outer COM standby frequency selector down
D	Turns inner COM standby frequency selector down
F	Toggles both flight director switches
G	Cycles gear lever: DN, OFF, UP, OFF, ...
H	COM push-to-talk switch
J	Sets both pilot clocks to simulated earth's UTC
K	Moves gear steering tiller (or rudder pedal if >50 kt) left
L	Moves gear steering tiller (or rudder pedal if >50 kt) right
K + L	If >50 kt, neutralizes rudder pedals to trimmed position
(country spec.)	Flap alert override switch
(country spec.)	Gear alert override switch
(country spec.)	Terrain alert override switch
Enter	Master warning reset switch & G/S alert inhibit switch
Shift *(left)*	Connects keyboard to CDU L, or disconnects any connected CDU.
Z	PVD switch
X	Sets MCP HDG to next suitable runway heading
C	Cycles chronograph: Start, stop, reset, ...
V	Causes PNF to say next checklist item
B	Park brake lever
N	Sets all altimeters to QNH of nearest airport, or STD when above TA/TL.
M	Freezes aircraft motion, including gear strut compression.
(country spec.)	Turns autobrake selector left
(country spec.)	Turns autobrake selector right
(country spec.)	TFC switch
Shift *(right)*	Connects keyboard to CDU R, or disconnects any connected CDU.
Space	Pushes both brake pedals
Delete	Pushes left rudder pedal
End	Neutralizes rudder pedals to trimmed position
PgDn	Pushes right rudder pedal
ArrowL	Turns aileron control wheel left
ArrowR	Turns aileron control wheel right
ArrowUp	Moves elevator stick forward
ArrowDn	Moves elevator stick aft
1 ... 9	*(numeric pad)* Selects one of nine layouts
0	*(numeric pad)* Reloads last layout file
Enter	*(numeric pad)* Master warning reset switch & G/S alert inhibit switch
Minus	*(numeric pad)* Pushes alternate stabilizer trim switches to nose down
Plus	*(numeric pad)* Pushes alternate stabilizer trim switches to nose up

(continued next page)

Keyboard – Summary: *(continued)*

Ctrl + F1 *	THR switch
Ctrl + F2 *	SPD switch
Ctrl + F3 *	LNAV switch
Ctrl + F4 * **	VNAV switch
Ctrl + F5 *	FLCH switch
Ctrl + F6 *	HDG HOLD switch
Ctrl + F7 *	V/S switch
Ctrl + F8 *	ALT HOLD switch
Ctrl + F9 *	LOC switch
Ctrl + F10 *	APP switch
Ctrl + J	CMD L switch
Ctrl + K	CMD C switch
Ctrl + L	CMD R switch
Ctrl + Q	IAS/Mach blank switch
Ctrl + W	IAS/Mach SEL switch
Ctrl + E	Turns IAS/Mach selector by –10 units
Ctrl + R	Turns IAS/Mach selector by +10 units
Ctrl + T	HDG SEL switch
Ctrl + U	Turns bank limit selector left
Ctrl + I	Turns bank limit selector right
Ctrl + O	Turns HDG selector by –10°
Ctrl + P	Turns HDG selector by +10°
Ctrl + A	Turns V/S selector by –1000 fpm
Ctrl + S	Turns V/S selector by +1000 fpm
Ctrl + D	ALT switch
Ctrl + F	Turns ALT selector by –1000 ft
Ctrl + G	Turns ALT selector by +1000 ft
Ctrl + Enter	ND CTR switch
Ctrl + Backspace	Elapsed time (ET) reset switch
Ctrl + Shift	Connects keyboard to CDU C
Ctrl + Del	Sets rudder trim selector to slow left
Ctrl + Del + PgDn	Sets rudder trim selector to fast left
Ctrl + End	Rudder trim centering switch
Ctrl + PgDn	Sets rudder trim selector to slow right
Ctrl + PgDn + Del	Sets rudder trim selector to fast right
Ctrl + ArrowL	Sets aileron trim switch to left
Ctrl + ArrowR	Sets aileron trim switch to right
Ctrl + ArrowUp *	Sets yoke stabilizer trim switches to nose down
Ctrl + ArrowDn *	Sets yoke stabilizer trim switches to nose up

** May be inhibited in Apple OS X by user system preferences.*
*** Cannot be used in Microsoft Windows.*

(continued next page)

Keyboard – Summary: *(continued)*

Cmd + Q	Quits Precision Simulator in Apple OS X
Alt + F4	Quits Precision Simulator in Microsoft Windows
Alt + F1	Slowly advances thrust lever 1
Alt + F2	Slowly advances thrust lever 2
Alt + F3	Slowly advances thrust lever 3
Alt + F4 *	Slowly advances thrust lever 4
Alt + F5	Slowly advances all thrust levers
Alt + 1	Slowly retards thrust lever 1
Alt + 2	Slowly retards thrust lever 2
Alt + 3	Slowly retards thrust lever 3
Alt + 4	Slowly retards thrust lever 4
Alt + 5	Slowly retards all thrust levers
Alt + S	Reloads last loaded situation file
Alt + Q	Turns MINS selector by −1 ft
Alt + W	Turns MINS selector by −10 ft
Alt + E	Turns MINS selector by +1 ft
Alt + R	Turns MINS selector by +10 ft
Alt + T	Turns BARO selector by −1 unit
Alt + Y	Turns BARO selector by +1 unit
Alt + U	FPV switch
Alt + I	MTRS switch
Alt + O	VOR L switch
Alt + P	VOR R switch
Alt + D	MINS RST switch
Alt + G	MINS mode selector
Alt + H	BARO STD switch
Alt + J	BARO mode selector
Alt + K	Turns ND mode selector left
Alt + L	Turns ND mode selector right
Alt + A	Turns ND range selector left
Alt + Z	Turns ND range selector right

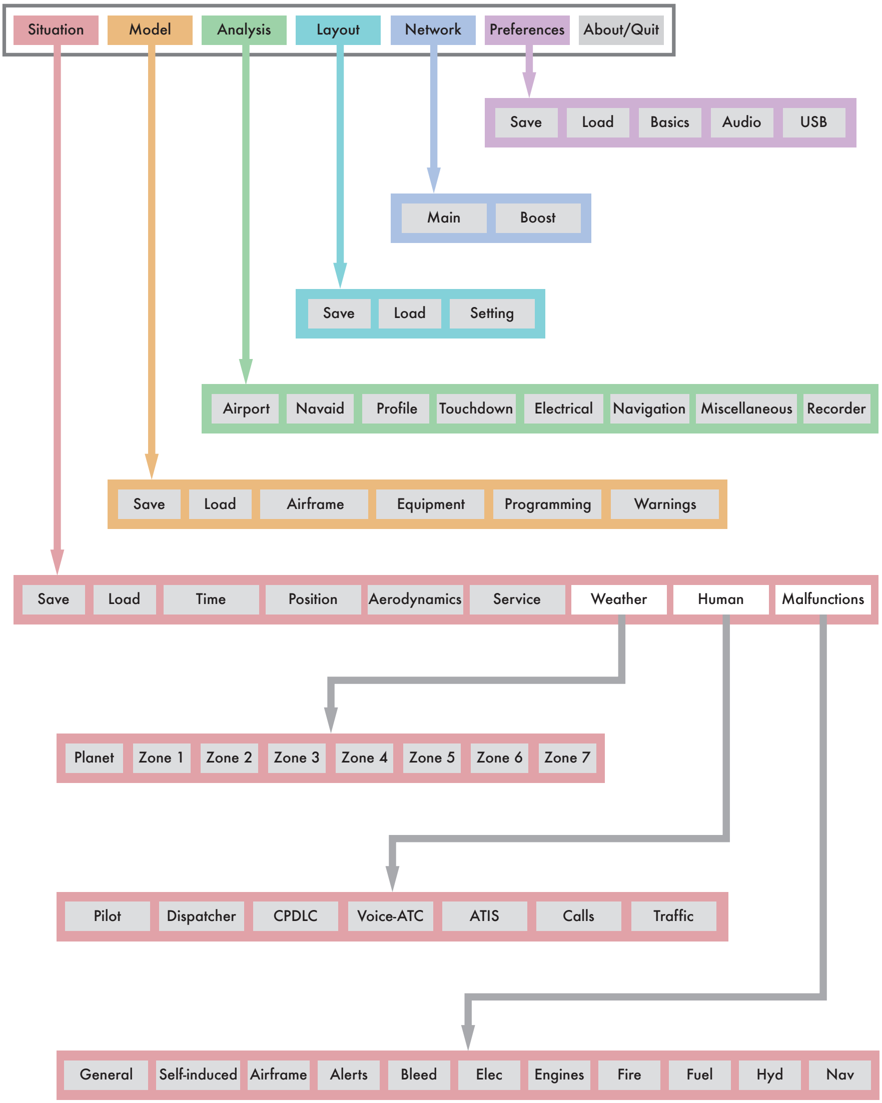
** Cannot be used in Microsoft Windows.*

(continued next page)

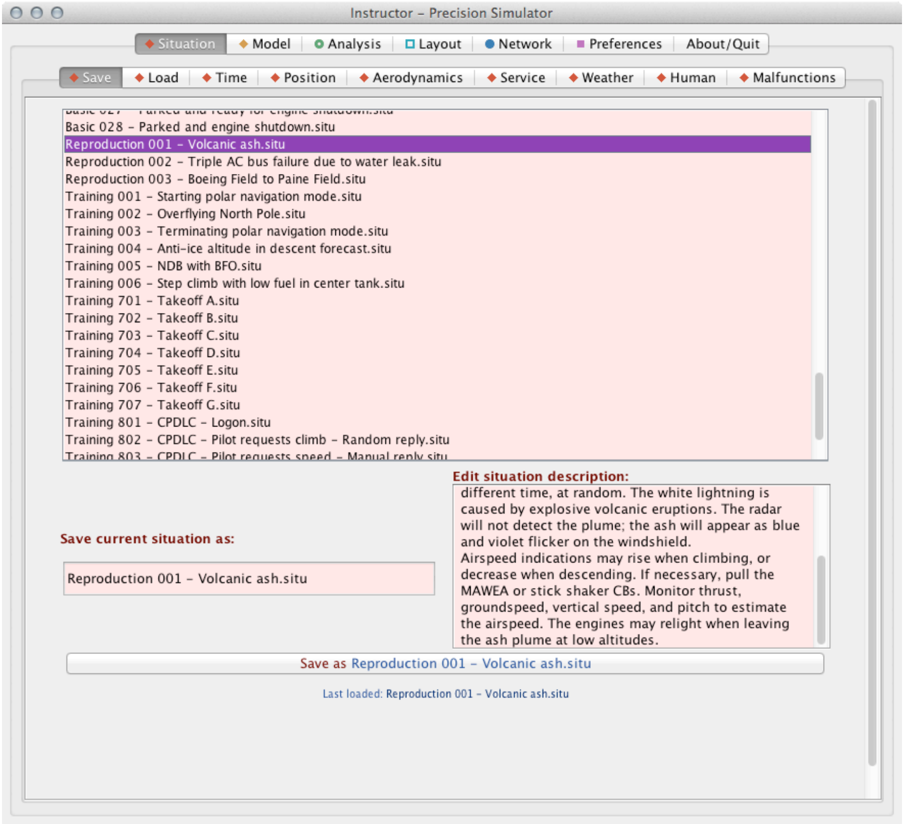
Keyboard – Summary: *(continued)*

Alt + X	WXR switch
Alt + C	STA switch
Alt + V	WPT switch
Alt + B	ARPT switch
Alt + N	DATA switch
Alt + M	POS switch
Alt + ,	TERR switch
Alt + F6	ENG switch
Alt + F7	STAT switch
Alt + F8	ELEC switch
Alt + F9	FUEL switch
Alt + F10	ECS switch
Alt + 6	HYD switch
Alt + 7	DRS switch
Alt + 8	GEAR switch
Alt + 9	CANC switch
Alt + 0	RCL switch

Instructor Pages – Overview:

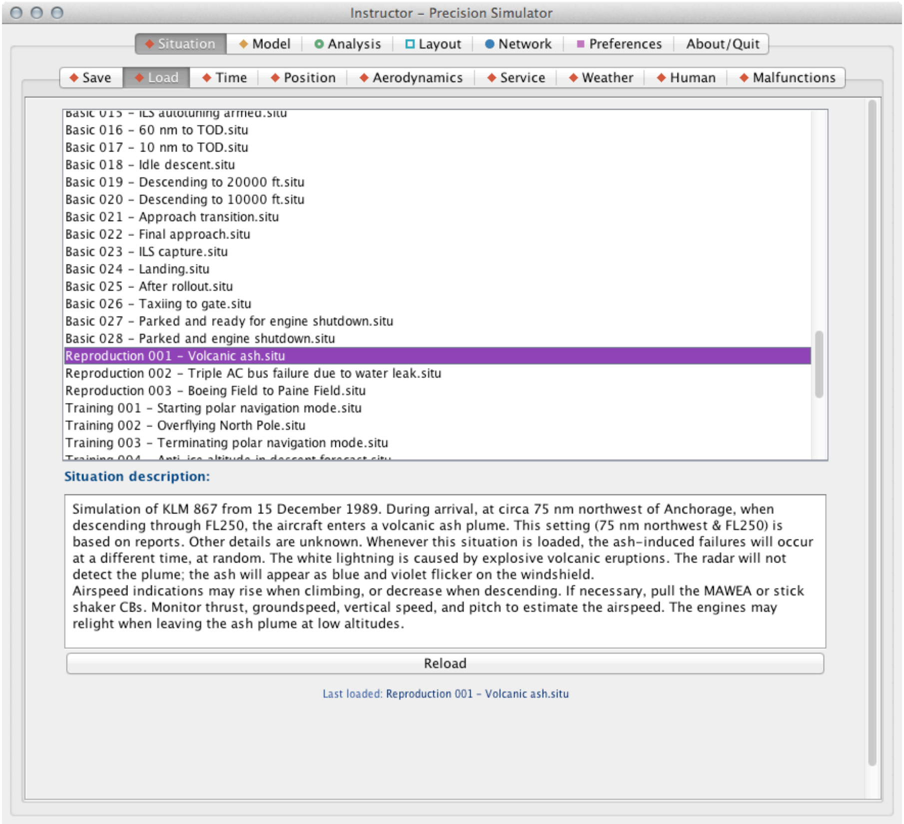


Instructor > Situation > Save:



- This page may be used to save all current situational data in a file for later reproduction. A situation file also stores the aircraft model data currently applied.
- When paused, saving is not possible; but it is possible when the motion is stopped.
- The lower right-hand text edit field allows you to add or edit a description. Selecting a file name from the list will not change your description.
- The name of the file to be saved can be edited in the lower left-hand edit field. The simulator will add a *.situ* suffix if it is not entered already.
- When the **Save as** button is clicked, the button label changes to **Confirm: Save as**, requiring a second click for confirmation. Only this second click will save the file. When not confirmed within 5 seconds, the button label is reset to **Save as**.
- To delete a file, select the respective file on the list, then press the **Delete** key on the keyboard. *Default.situ* cannot be deleted.

Instructor > Situation > Load:

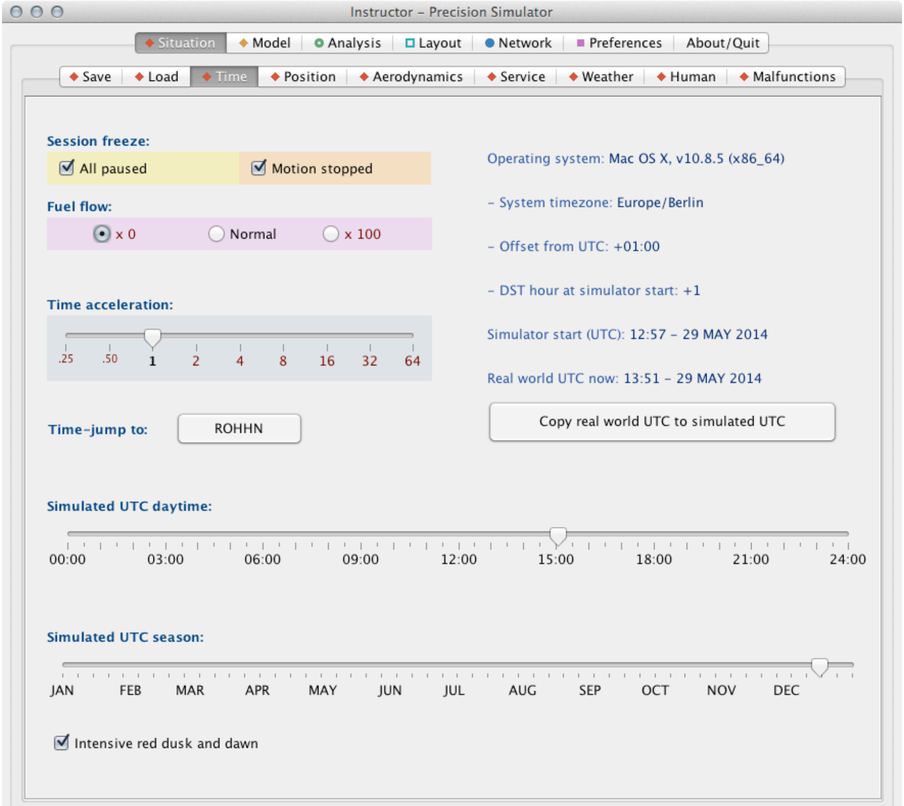


- This page may be used to load a situation file.
- To load a file, double-click the desired file on the list.
- The **Load** (or **Reload**) button may be used as well; it will load the file selected on the list.
- To delete a file, select the respective file on the list, then press the **Delete** key on the keyboard. *Default.situ* cannot be deleted.
- Files that contain a description starting with a command line like, for instance,

  AutoReload=110;

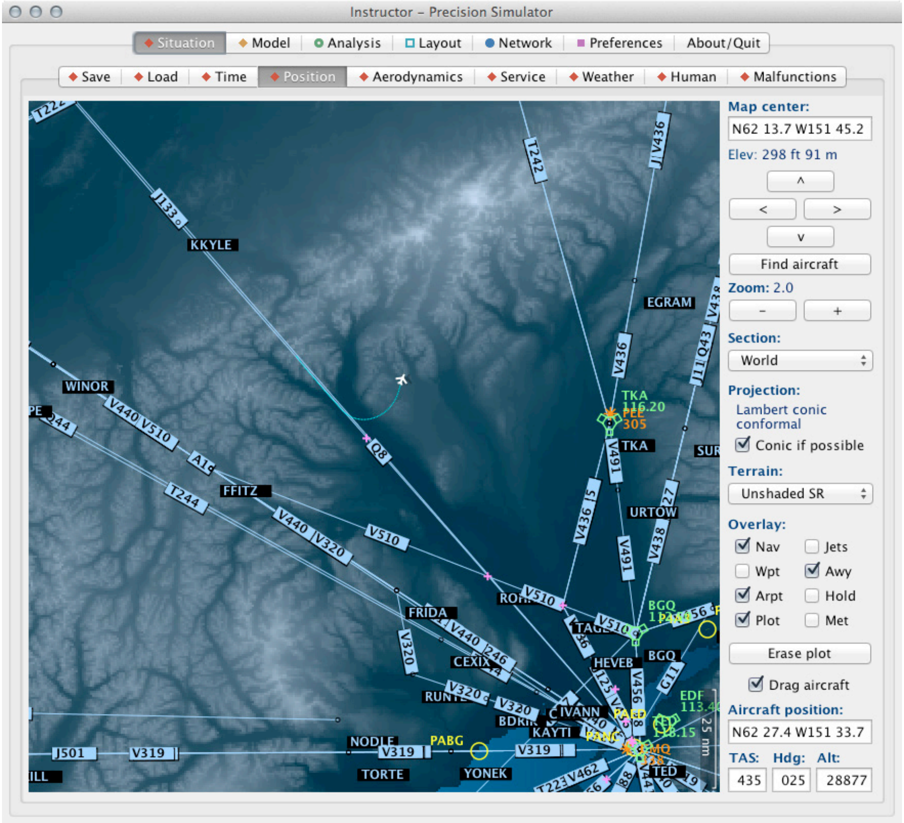
  will automatically self-reload after a specified time; in this example, after 110 seconds. The autoreload function may be used for demonstration loops at exhibitions, for instance.

Instructor > Situation > Time:



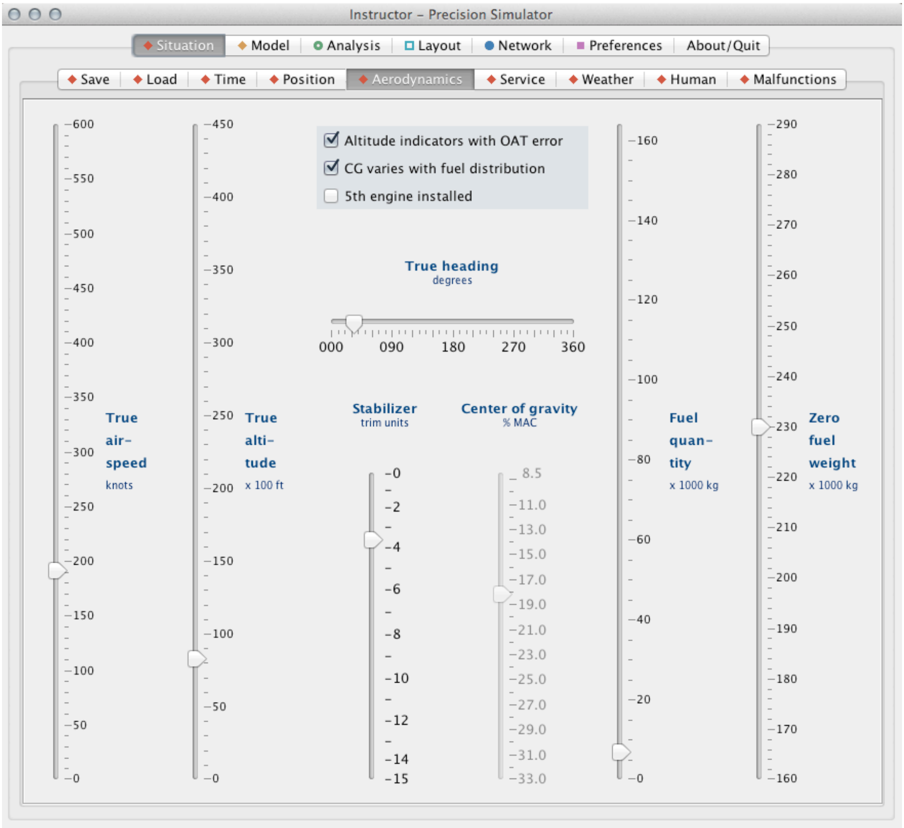
- Hover the mouse over an object on this page to show tooltips with descriptions.
- **Time-jump to** sets the simulated UTC, the aircraft altitude (and cabin altitude), position, track, speed, clocks, fuel, to the FMC-predicted values of the next waypoint. Configure your flaps and instruments before jumping between high-speed and low-speed legs.
- Use the pause function only if you need to pause the *entire* simulation. System training is not possible when paused. To keep the aircraft stationary with the systems running, just stop the motion. Note: When the motion is stopped while changing the aircraft's air-ground status by the Instructor tools, the air-ground relays may be locked (refer to **PSEU** in chapter **Landing Gear**). This is because the gear struts will remain compressed, or uncompressed respectively, when the motion is stopped. To release the lock, just unfreeze the motion.
- The time acceleration applies to all features except for audio, traffic, switch animations, and various flashing lights. WXR/TERR sweeps will blank when the time factor is above 4. Do not apply high factors in flight when the frame rate is low, else the time frame resolution will be too low for flight stabilization, and the aircraft may get out of control.

Instructor > Situation > Position:



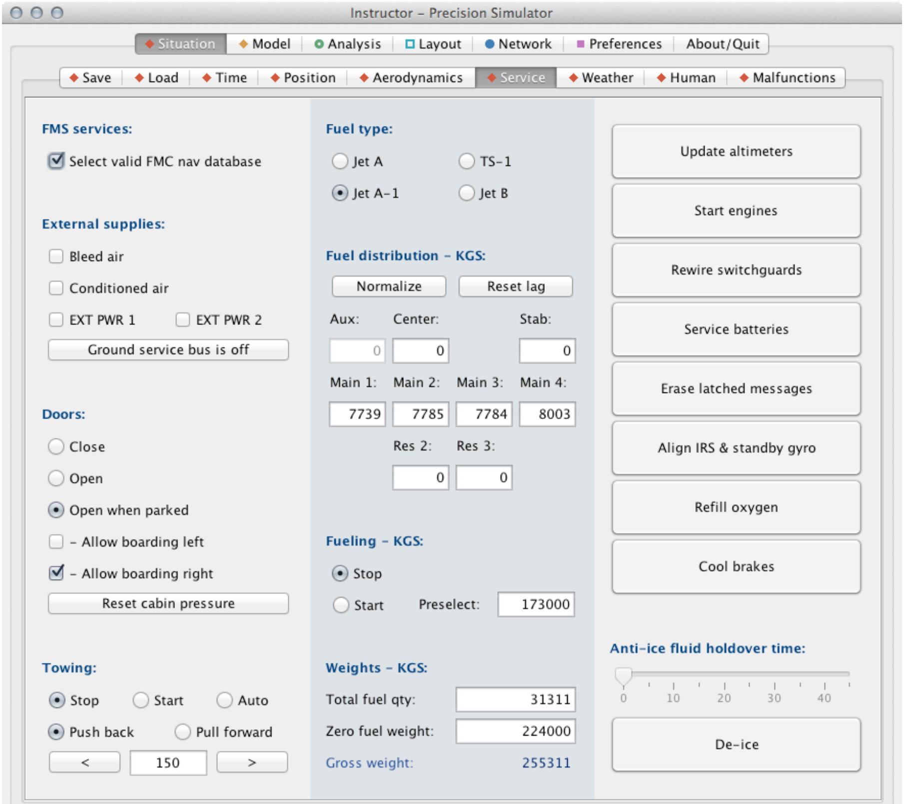
- Hover the mouse over a checkbox or button to show tooltips with descriptions.
- To change the zoom, hover the mouse over the map and turn the mouse wheel, or click the minus or plus button on the right-hand side of the page.
- When the **Drag aircraft** checkbox is deselected, the mouse is enabled to set the map center by a left-click on the desired target point. When the checkbox is selected, the aircraft can be repositioned by dragging the mouse (the cursor need not be on the aircraft symbol). Hold the ALT key if you want to freeze the aircraft heading while dragging. The **Drag aircraft** checkbox can also be selected and deselected by *right*-clicking the mouse on the map.
- To get further map centering tools, enter an airport ICAO code, or a navaid or waypoint identifier, in the **Map center** edit field.
- To get further aircraft repositioning tools, enter an airport ICAO code, or a navaid or waypoint identifier, in the **Aircraft position** edit field.

Instructor > Situation > Aerodynamics:



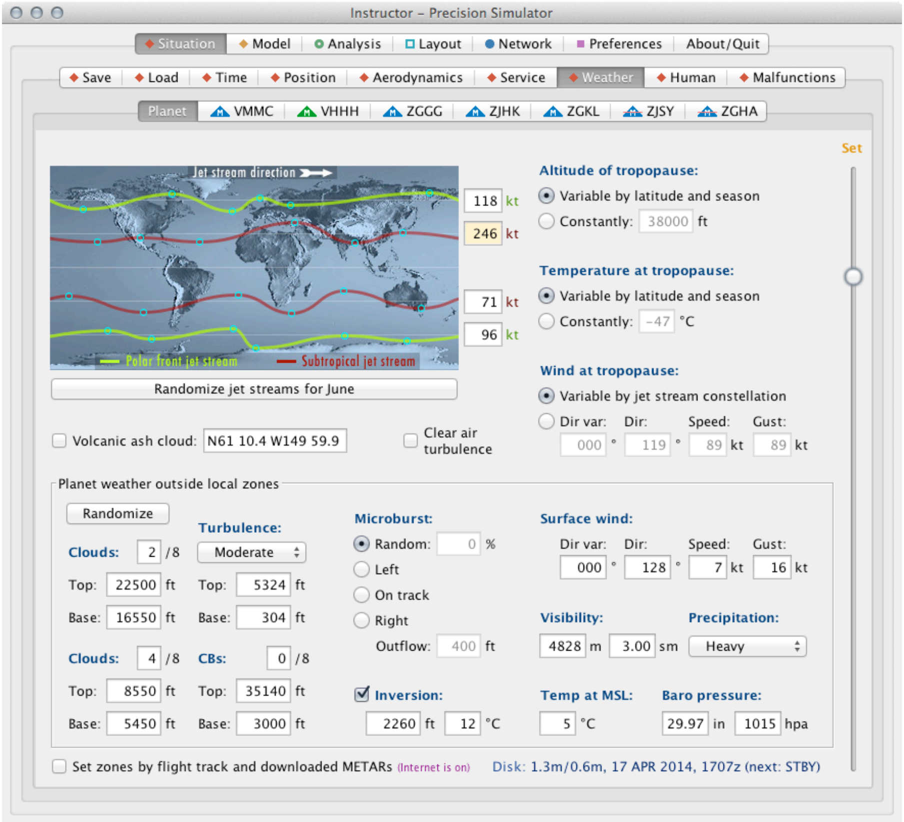
- Hover the mouse over a checkbox to show tooltips with descriptions.
- It is possible to set a speed or altitude outside the currently allowed range. The simulation will model the respective consequences.
- It is possible to set both weight sliders so that the gross weight exceeds the allowed limit. The simulation will model the respective consequences.
- The slider scales of the fuel quantity and zero fuel weight are adjusted automatically when aircraft options or weight units are changed.

Instructor > Situation > Service:



- Hover the mouse over an object on this page to show tooltips with descriptions.
- The **towing** simulation tows the aircraft to the entered target heading, and then continues on this heading until the towing is manually or automatically stopped. Proceed as follows:
  1. Under **Towing**, select **Start** or **Auto**.
  2. Set the parking brake.
  3. On your ACP, set the receiver selector (green light) to FLT and hold the INT switch for 2 seconds, or set the transmitter (MIC) to FLT and hold the R/T switch for 2 seconds. The 2-second phase simulates you calling the ground crew. Check your volumes are up.
  4. Ground: "*Steering pin inserted, release brakes, please.*"—Release the parking brake.
  5. Ground: "*Pushing back.*" (You may now start the engines.)
  6. If **Start** is selected under **Towing**, select **Stop** when you want to stop the towing. If **Auto** is selected, it will stop automatically after 2 minutes.
  7. Ground: "*Set parking brake, please.*"—Set the parking brake.
  8. Ground: "*Towing system removed and steering pin removed.*"—Towing is completed.

Instructor > Situation > Weather > Planet:

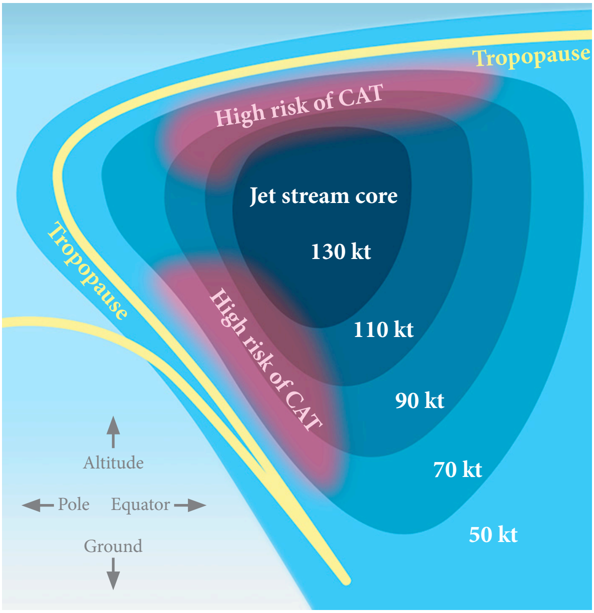


- Hover the mouse over an object on this page to show tooltips with descriptions.
- The vertical slider on the right-hand side may be used to set the value in the last focussed edit field. An edit field can be focussed by cycling the Tab key, or by left-clicking the mouse on the desired edit field. The edit field assigned to the slider will be marked in orange.
- The **jet stream constellation** shown on the small map can be modified by dragging the cyan circles with the mouse, or by clicking the **Randomize** button which will randomize the jet stream trajectories and speeds suitable to the currently simulated season set on **Instructor > Situation > Time**. Around July, the northern hemisphere jet streams are weaker and located farther away from the equator, while the other two are stronger and located closer to the equator. Around January, it is reversed. Overall, compared to the polar front jet streams, the subtropical ones are often weaker and are located at higher altitudes.—The jet stream model is active when **Variable by jet stream constellation** is selected under **Wind at tropopause**.

(continued next page)

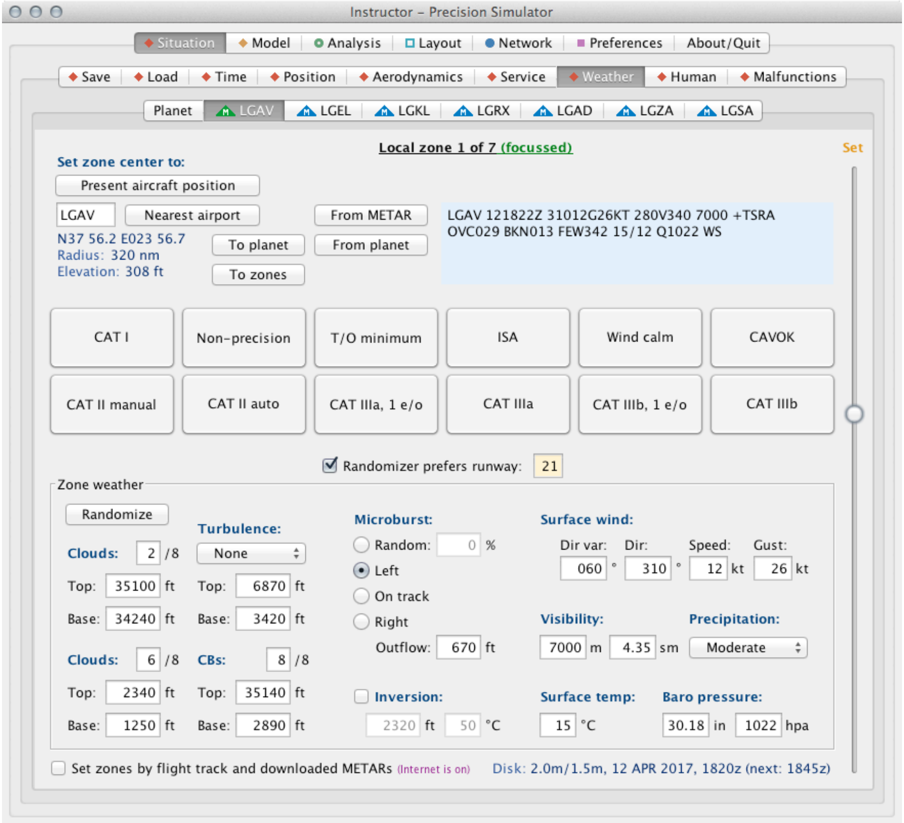
Instructor > Situation > Weather > Planet: *(continued)*

- The jet stream constellation does not only influence the winds near the jet stream cores, it influences the wind model of the *entire planet*. The jet streams are always directed from west to east. Near the equator, in the middle between the two subtropical jet streams, there is a weaker, opposite stream (not shown on the maps), directed from east to west; that area is also known as the intertropical convergence zone (ITCZ).
- The model places the ITCZ trajectory in the middle between the two subtropical jet streams. For example, if the longitude W100° is crossed by the northern subtropical jet stream at N40°, and by the southern subtropical jet stream at S20°, the ITCZ will cross W100° at N10° since N10° is in the middle between N40° and S20°. As the jet stream trajectories are not linear, every longitude will be crossed at different latitudes.
- The wind directions between the ITCZ and the subtropical jet streams are gradually interpolated: on the northern hemisphere, when approaching the equator, the wind directions turn clockwise; on the southern hemisphere, when approaching the equator, they turn anti-clockwise.
- In the vertical model, the maximum wind speed is reached at the tropopause, where it will never drop below circa 45 kt. Winds between the ground and the tropopause are smoothly interpolated, with the wind directions rotating clockwise with the altitude on the northern hemisphere, and vice versa on the southern hemisphere. The wind speeds rise drastically near the jet stream cores which are typically less than 5 miles thick. The cores are always at the tropopause, and cut a break into the tropopause profile:



This illustration shows the cross section through an idealized jet stream. When the aircraft crosses the magenta areas, the wind speeds will change very quickly, and there will be a high probability of clear air turbulence (CAT). In the simulator, to enable the risk of CAT in these areas, select the **Clear air turbulence** checkbox on the Planet page; the checkbox is enabled when the jet stream model is active. When the aircraft encounters CAT, the checkbox label is red.

Instructor > Situation > Weather > (Zone):



- Hover the mouse over an object on this page to show tooltips with descriptions.
- There are seven Zone pages. In the 3-dimensional space, a zone is a cylinder with a maximum radius of 320 nm, ranging from the ground up to 50000 ft. The zones generate the weather around the aircraft and are accordingly represented on the weather radar, and also influence the simulated ACARS weather data uplinks. The weather outside these zones is generated by the weather settings on the Planet page. A zone may be deactivated by entering four dashes "----" in the **Zone center** edit field. When a valid airport ICAO code is entered in this field, the center coordinates of this zone will be moved to that airport. When the aircraft is within this zone, the aerodynamics and the windshield view refer to this zone's weather. In other words, this weather is then the *focussed* weather. When multiple zones lie within 320 nm of the aircraft, the nearest zone will be focussed.

(continued next page)

Instructor > Situation > Weather > (Zone): *(continued)*

- When the checkbox **Set zones by flight track and downloaded METARs** is selected on the Planet page or on a Zone page, the simulator searches the vicinity of the aircraft for the seven nearest METAR stations (most of them are located at airports and use airport ICAO codes). The simulator will repeat the search every 7 nm along the flight track. Whenever new METAR stations are found, new zones will be created at the coordinates of these stations, and the weather in these zones will be set by the respective latest METAR data stored on the hard disk.
- When the checkbox **Allow METAR files download from Internet** is selected on **Instructor > Preferences > Basics**, the METAR data stored on the hard disk will be updated approximately twice an hour, provided the computer on which the simulator runs is connected to the Internet (in a local Precision Simulator network, however, only the Precision Simulator *server*—not the clients—must have access to the Internet). At the bottom of the Weather pages, a status line indicates, for instance:

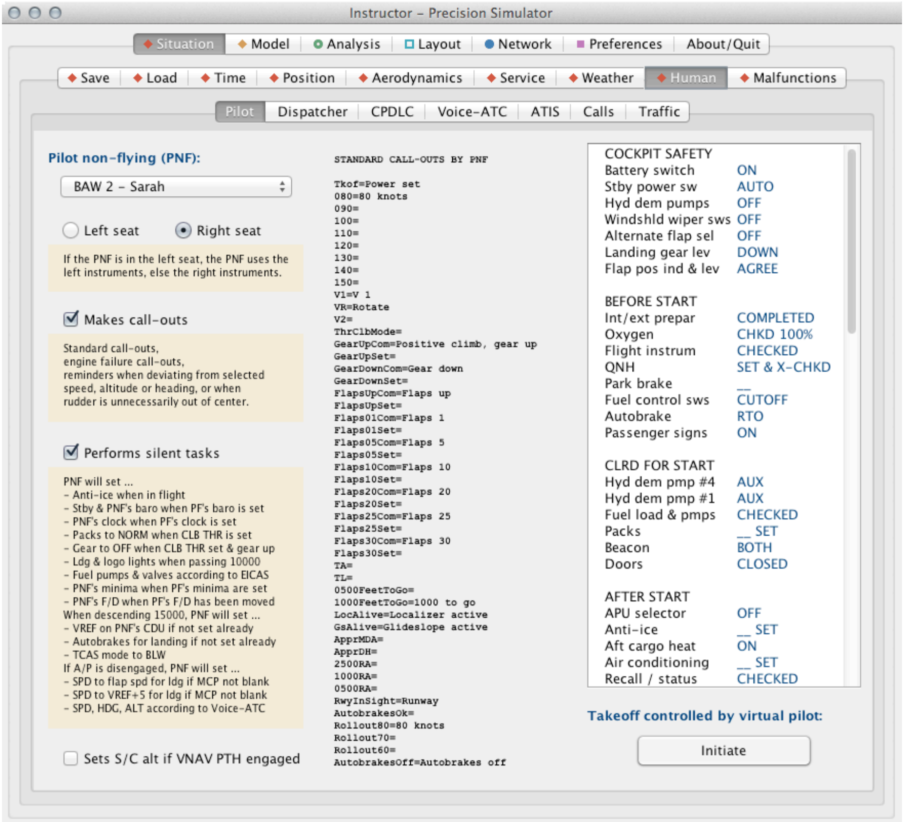
  Disk: 1.3m/0.8m, 05 JUN 2014, 2115z (next: 2144z)

  This example indicates: the METAR data files (there are two on the hard disk) are currently 1.3 mb and 0.8 mb in size (1.3 mb is the typical size of a complete world file); the last download was executed on 5th June 2014, 21:15 UTC; the next download will start at 21:44 UTC.

  Note: During every simulator start, all METAR files in the *Weather* subfolder, except for the latest two files, will be deleted. METAR files have the suffix *.metar*.
- In summary: when the checkbox **Set zones by ...** is selected, the zones may be updated in flight track intervals and in time intervals. Whether in space or in time—the data will always transit smoothly and slowly inside the physical simulation. For instance, when the QNH changes from 990 to 1000 hpa, the page will promptly indicate 1000, but the physical environment around the aircraft will transit to 1000 hpa very slowly. When a transition is in progress, the message "smooth transit" appears in magenta in the page header, and the tab shows a magenta triangle. When the transition is completed, the triangle turns green, and the header indicates "focussed" in green.
- The zone pages can be manually edited only when the checkbox **Set zones by ...** is deselected. There are two ways of editing the data: change the METAR text in the upper right-hand edit field—or use the other controls on the page. A *smooth* data transit is started when the METAR text is changed (by the user or by an injecting add-on)—a *quick* data transit is started when the other controls are used.
- M-labels in the tabs indicate the manual mode is active; A-labels indicate the automatic mode is active. The colors indicate which zone has the focus:

M	A	*Magenta:*	This zone is focussing; that is, the smooth transit is in progress.
M	A	*Green:*	This zone is focussed.
M	A	*Others:*	This zone is not focussed.
M	A	*Dashed:*	This zone is more than 320 nm away from the aircraft, and hence, cannot be focussed; or it is deactivated because the entered station is not found in the database.

Instructor > Situation > Human > Pilot:



- Click on the combo box under **Pilot non-flying (PNF)** to select a voice and an associated, airline specific call-out and checklist schedule. The checklist calls can be sequenced infinitely by the V key (say the next item) and the R key (return to the last checklist title).
- When the checkbox **Sets S/C alt if VNAV PTH engaged** is selected, and the aircraft overflies a step climb (S/C) point, the PNF will set the MCP altitude to the next FMC step-to altitude and push the MCP altitude knob to initiate that step climb.
- The airline specific standard call-out schedule is displayed in the middle of the page, and the checklists are shown on the right-hand side and can be scrolled. These schedules are stored on the hard disk in the subfolder *Audio/Pilots* in individual **.pilot* files. The simulator accepts further, user defined **.pilot* files and related **.wav* files. If you like to add your own audio files, note that the sound format must be in **mono** (to allow panning). Also keep the file sizes small by using low sample rates; this decreases the loading time and saves memory.

(continued next page)

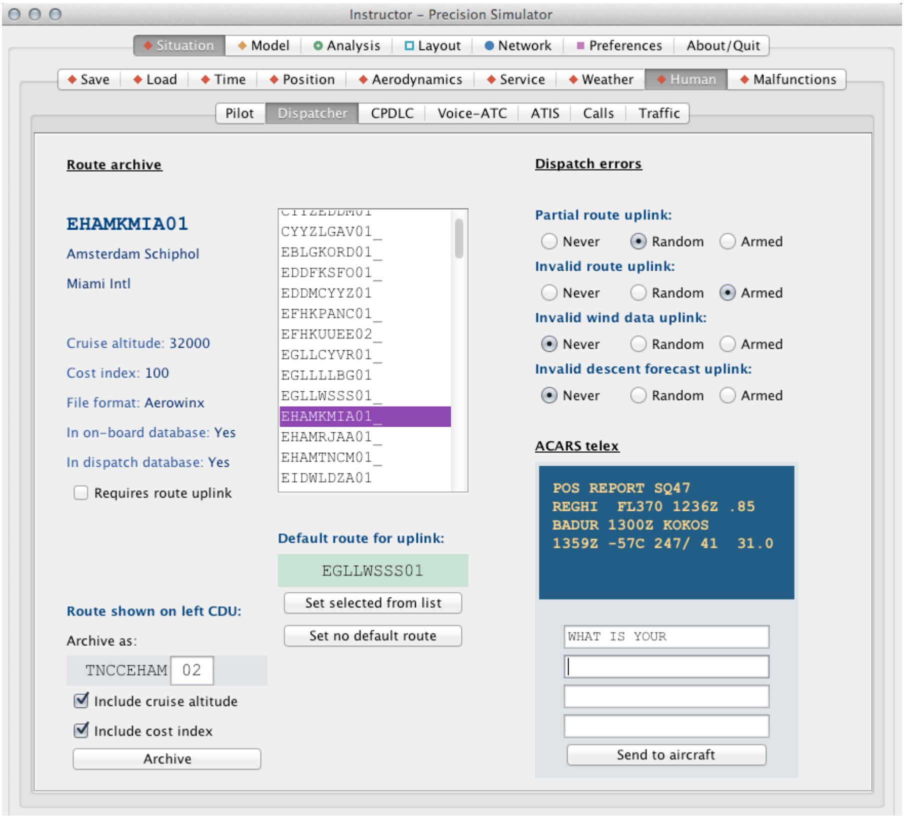
Instructor > Situation > Human > Pilot: *(continued)*

- **Takeoff controlled by virtual pilot**: This is a simulation of a human pilot handling the takeoff manually. It may be helpful when you are using the simulator for systems training only, or for crew coordination exercises, or if you want to learn how the controls need to be deflected under crosswind or asymmetric thrust conditions (watch the flight control indications). The feature is enabled when the aircraft is ready for takeoff, and can then be started by hitting the F11 key (if the flightdeck is shown) or by clicking the **Initiate** button on the Pilot page. When started, the button is labeled with **Disable**, and the aircraft will be controlled from the left or right seat as selected by the **Left seat** or **Right seat** checkbox. The seat selection is relevant because the virtual pilot may react to malfunctions of the left or right instruments accordingly, and will even perform a rejected takeoff if necessary (depending on speed and alert level). The virtual pilot can handle strong crosswinds as well as engine-out takeoffs; the reaction and decision time of the virtual crew member is about equal to that of a real pilot, that is, circa 900 ms. You are the monitoring pilot and you have to make your airline specific call-outs, for example *"Power set!"* when the thrust is stabilized, then *"80 knots!"* (to which the virtual pilot normally responds with *"Checked!"*), and finally *"V1!"* and *"Rotate!"* at the respective speeds. When the climb rate is positive the virtual pilot calls *"Gear up!"* and you have to move the gear lever to the UP position. At 400 ft above the runway the virtual pilot engages one of the autopilots and calls *"Your control!"* to which you need to reply with *"I have control!"* If the virtual pilot performs a rejected takeoff, the control will be transferred to you when the aircraft has stopped.

  The **Initiate** button is disabled when any of the following conditions is true:
  - Time acceleration factor higher than 1
  - Active FMC route contains no departure runway
  - A/T ARM switch off
  - AFDS status not F/D
  - Pitch mode not TO/GA
  - Aircraft not on ground
  - Groundspeed higher than 10 kt
  - Any gear not down
  - Flap lever not at 10 or 20
  - Any thrust lever more than 5° out of idle
  - Any EICAS warning, caution, or advisory message exists
  - Aircraft offset from runway centerline greater than 100 ft
  - Aircraft distance from published takeoff position greater than 9000 ft
  - Difference between runway heading and aircraft heading greater than 20°
  - Any engine not running

  At any time, you can transfer the aircraft control back to you by any of the following actions:
  - Hit the F11 key (if the flightdeck is shown) or click the **Disable** button
  - Deflect your aileron, elevator, or rudder control by more than 30%
  - Retard any thrust lever below takeoff power when IAS is greater than 70 kt
  - Push a brake pedal when takeoff power is set or when groundspeed is above 20 kt
  - Actuate any MCP switch

Instructor > Situation > Human > Dispatcher:



- The list in the center shows all files stored in the *Aerowinx/Routes* subfolder. You may delete a file by selecting a file name on the list, and then pressing the **Delete** key on the keyboard.
- A route file name must consist of 10 characters, optionally followed by an underscore "_" (11th character), and, additionally, it must end with the *.route* suffix which is hidden on this list. Only the first 10 characters appear on the FMC pages as a route identifier.
- If the checkbox **Requires route uplink** is *deselected* for a certain route, the 11th character in the file name will be an underscore "_" (signaling the file is on board); otherwise, the underscore "_" will be absent (signaling the file is *not* on board). When a route identifier is entered on the FMC RTE page in the CO ROUTE line, and this route file is not on board, the simulator will model the ACARS route uplink process.
- It is possible to create a route identifier with less than 10 characters. For example, archive a file as *KSFOKLAX01*. In your operating system, it will appear as *KSFOKLAX01.route*. Rename it to *SFOLAX01 .route* (with two spaces before the *.route* suffix).

(continued next page)

Instructor > Situation > Human > Dispatcher: *(continued)*

- The FMC model in Precision Simulator is able to load **two types of route file formats**: The *Aerowinx* format, and the *PFPX* format by *flightsimsoft.com* (the *PFPX* format is loaded by the FMC model as is, without any prior file conversion; the export function in the *PFPX* program just copies an unconverted *PFPX* file to the *Aerowinx/Routes* subfolder).
- **Route shown on left CDU**: Clicking the **Archive** button in the lower left-hand corner of the Dispatcher page will store the respective route in the *Aerowinx/Routes* subfolder. If that route already exists, the button label reads **Overwrite**. The route to be archived, shown on the left CDU, may be route 1 or route 2, and may be active, inactive, or modified.
- **Default route for uplink**: When a default route identifier is shown in the green box in the center of the Dispatcher page, that route is ready to be sent ("uplinked") from the dispatch office on the ground up to the aircraft's flight management computers. The pilot can then request this route by pushing the REQUEST SEND key on the first FMC RTE page (of route 1 or 2) even if there is a different route identifier entered in the CO ROUTE line on that same FMC RTE page; the CO ROUTE line is only effective when the dispatcher is *not* providing a default route, or if the entered CO ROUTE identifier refers to a route that is stored in the on-board database. For more information refer to the **RTE Page** descriptions in the chapter **FMS**.

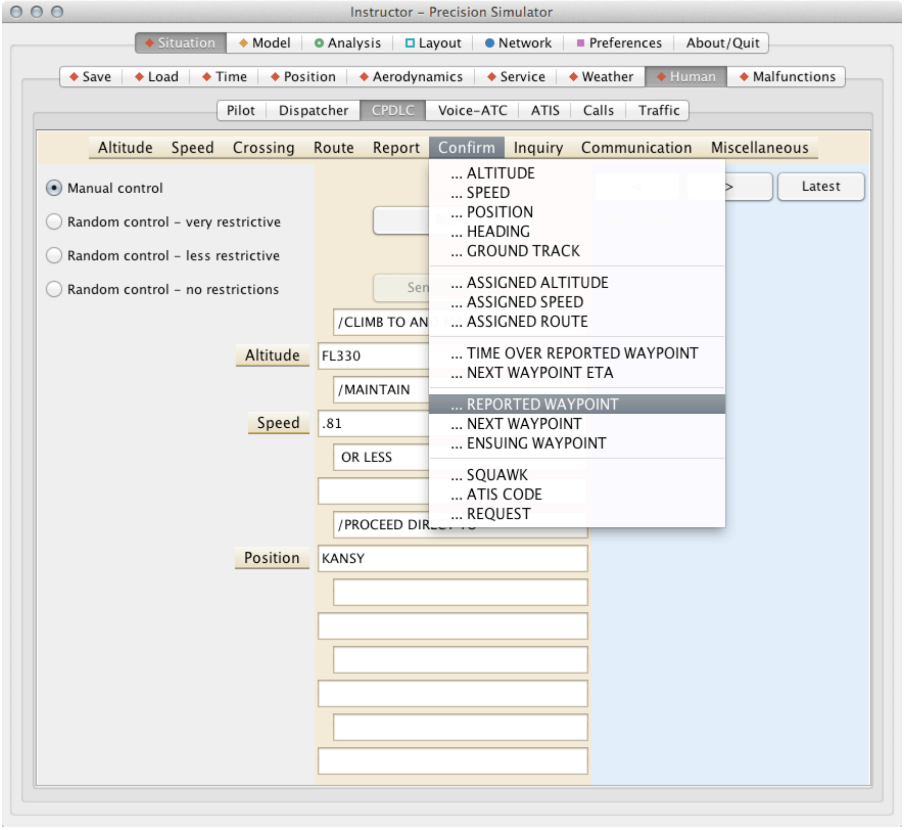
  To set a default route identifier in the green box, click a route identifier on the list in the center of the Dispatcher page, then click the button **Set selected from list**. If a default route should not be provided, clear the green box by clicking the button **Set no default route**.
- **Dispatch errors**: These are simulations of uplink errors in the dispatch system. When such an error occurs during an uplink, the pilot will be notified by a related FMC message (refer to the **FMC Scratchpad Messages** table at the end of the chapter **FMS**). The simulation provides four types of uplink errors: Partial route, invalid route, invalid wind data, and invalid descent forecast. Each error type is grouped with three checkboxes which provide the following functions:

  Never: The respective error will never occur.

  Random: In every uplink, the error may occur randomly at a probability of 20%.

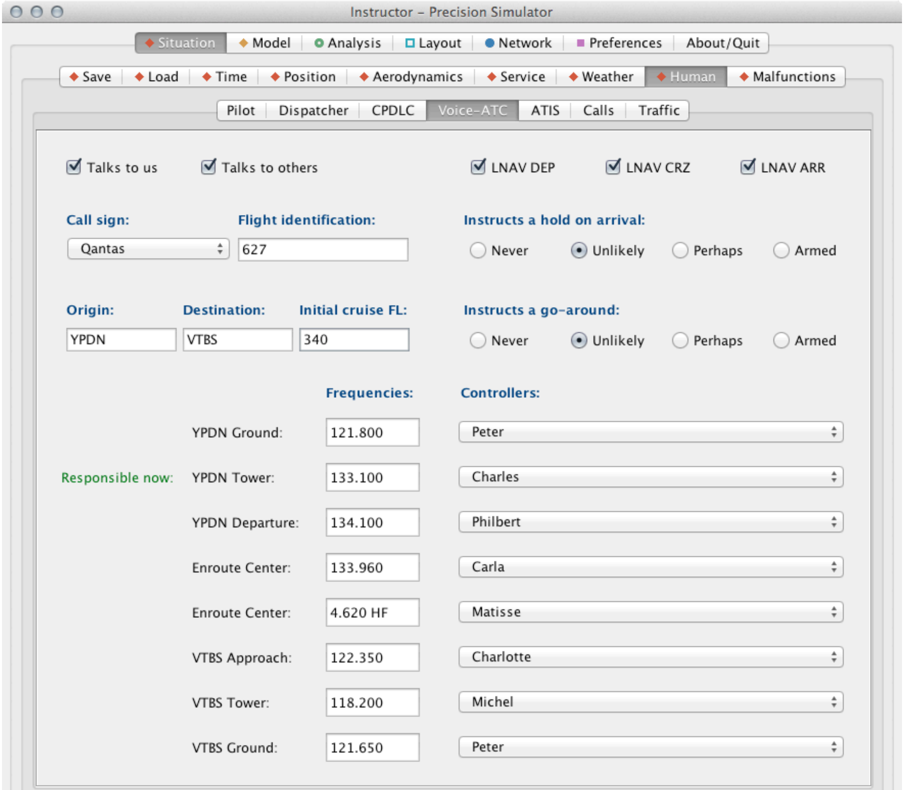
  Armed: The error will occur in the next uplink, and the checkbox selection will then automatically be reset from **Armed** to **Never**.
- **ACARS telex**: The blue screen shows the last telex message sent from the aircaft down to the dispatch office ("downlinked" message). There is no message buffer; the latest message always overwrites the previous one. The white edit fields allow the dispatcher to write four text lines, each with a maximum of 24 characters, for a telex message that is to be uplinked to the aircraft; the uplink can be started by clicking the **Send to aircraft** button. For further details refer to the **ACARS** section in the chapter **Communications**.

Instructor > Situation > Human > CPDLC:



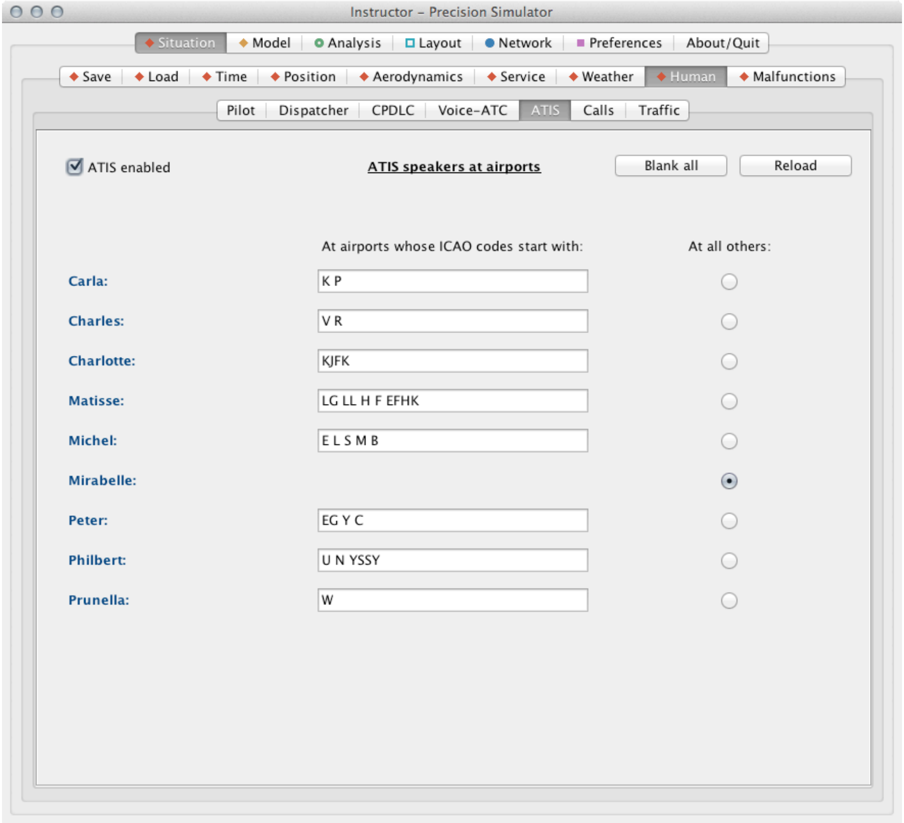
- This page contains an extra menu bar, allowing a controller to select standard CPDLC text elements. The selected text elements will be transferred to the edit fields in the middle of the page. These fields can also be edited manually. The uplink to the pilot will only work when the aircraft systems are correctly configured (refer to chapter **FMS** and chapter **Communications**).
- The right-hand side of the page shows the controller's message log. Additional buttons occur in the message log area when a downlink is to be answered by **Standby**, **Unable**, or **Respond**.
- Note that situation files only store the latest message; that is, when a situation file is loaded, no more than one message will be in the log initially.

Instructor > Situation > Human > Voice-ATC:



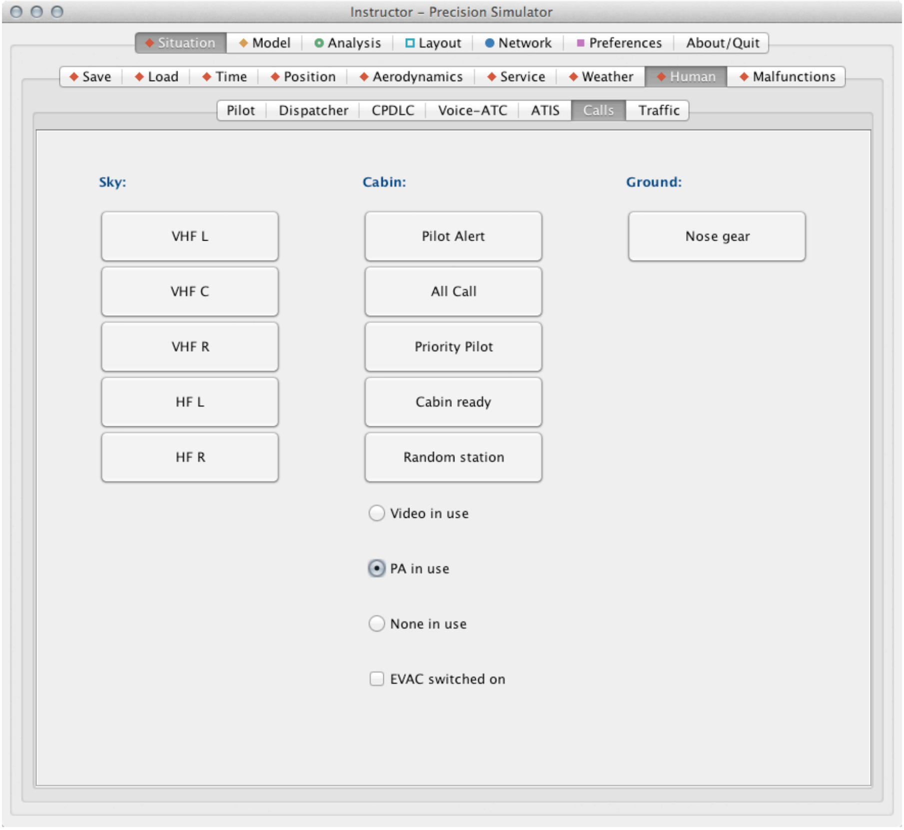
- ATC dialogs are enabled when the **Talks to us** checkbox is selected. To call ATC, tune the frequency of the controller that is responsible now (indicated in green), set your ACP as required (refer to chapter **Communications**), then hold one of your PTT switches for a moment to simulate a call. You may say the standard ATC phrases aloud or in your head.
- To simulate a *"Say again"* request, click your PTT switch twice within 1 second.
- You must confirm every instruction by momentarily pressing your PTT switch; otherwise, the controller will, in most cases, repeat the last instruction two or three times. Again, while pressing your PTT switch, you may read back each instruction aloud or in your head.
- If you want the ATC instructions not to interfere with your planned LNAV route, select the checkboxes **LNAV DEP**, **LNAV CRZ**, **LNAV ARR** for the respective flight phases.
- The two enroute frequencies are random generated when on the ground: the first one is generated when an origin is entered, the second one when a destination is entered. All eight frequencies can be manually edited.
- ATC will not talk to us when CPDLC is in use, or when the squawk is 7500, 7600, or 7700.

Instructor > Situation > Human > ATIS:



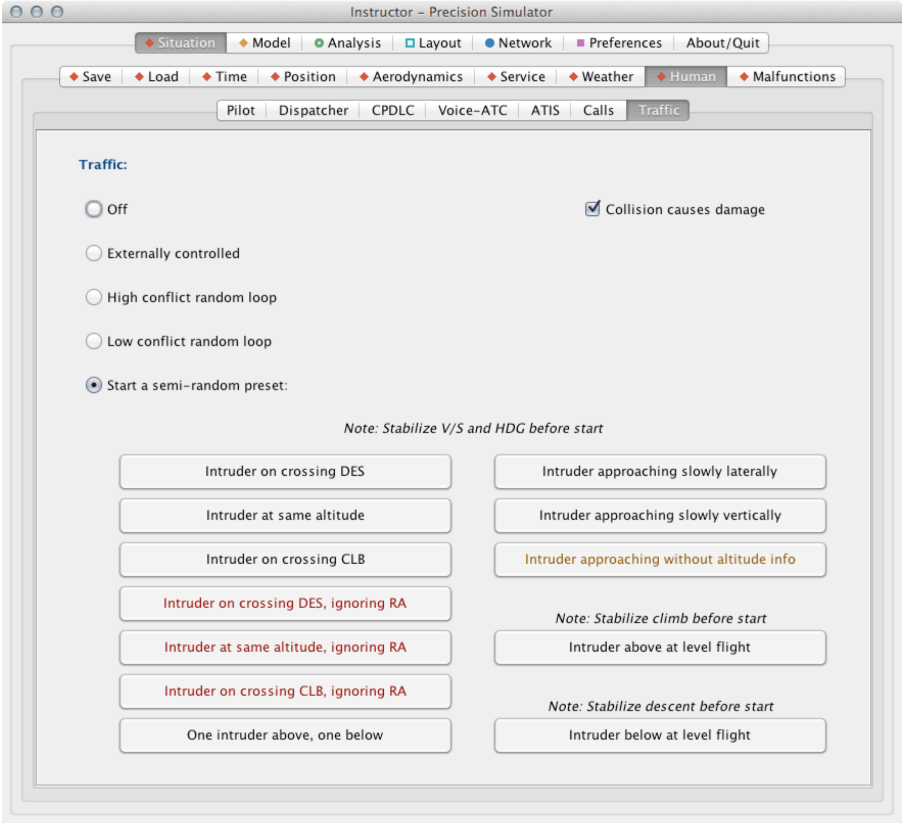
- There are three original audio sets labeled as *Charlotte*, *Michel*, and *Peter*. The other six sets are clones of the original three, and are played back at different sampling rates, so that the clones' voices are slightly higher and faster, or lower and slower, in order to provide a greater variety during the flight. The same principle is applied to the voice-ATC simulation described on the previous page.
- The **Reload** button reloads the page setting stored in the last loaded situation file.

Instructor > Situation > Human > Calls:



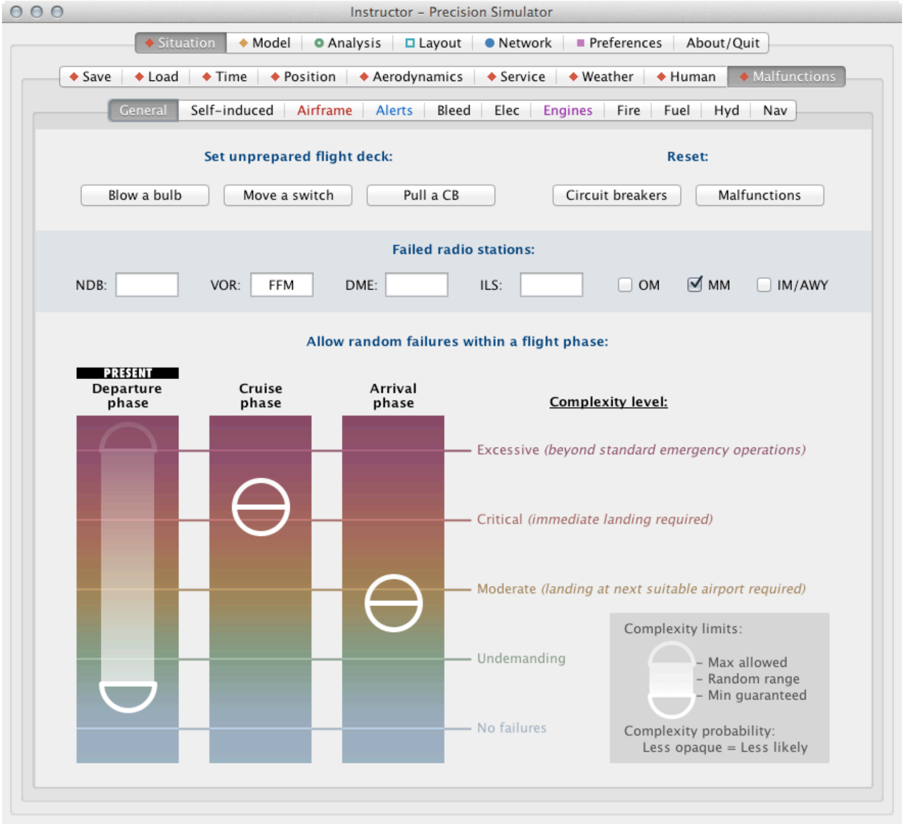
- This page provides buttons to activate SELCAL chimes and lights on VHF and HF.
- This page may also be used to simulate calls from the cabin and the nose gear station which will activate certain interphone chimes, lights, and call panel displays (refer to chapter **Communications**).
- The functions on this page do not generate speech. Speech is only generated when a station is called from the flight deck.
- The checkbox **EVAC switched on** refers to an EVAC switch outside the flight deck at a cabin door (refer to chapter **Emergency Equipment**).

Instructor > Situation > Human > Traffic:



- Select **Externally controlled** when an add-on injects traffic data.
- Select **High conflict random loop** for random TCAS training during a normal flight.
- Select **Low conflict random loop** to keep the conflict probability low.
- Select **Start a semi-random preset** to keep the conflict probability extremely low. This selection also enables the buttons in the lower half of the page. Pushing such a button generates a single conflict, and thereafter keeps the conflict probability extremely low.
- In most cases, for coordinated escape maneuvers, the pilots of the intruder aircraft will follow their resolution advisory (RA) of their onboard TCAS. However, if you click a *red* preset button (*"ignoring RA"*) on the page above, the intruder will always escape into the wrong direction, making the situation even more dangerous.
- To test the general visual aspects of the traffic simulation, push a preset button while holding the ALT key on the keyboard. This will initiate various formation flights.

Instructor > Situation > Malfunctions > General:



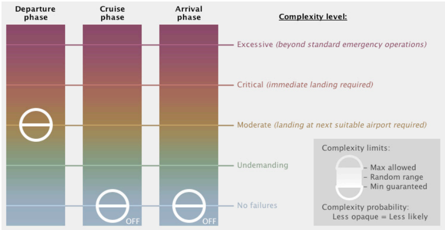
- Clicking a button under **Set unprepared flight deck** respectively blows an indicator bulb, moves a switch, or pulls a circuit breaker—at random—, provided the randomizer hits an item that is not affected already.
- **Reset**: The **Circuit breakers** button resets all CBs that are not locked out by a red security ring; the **Malfunctions** button disarms all armed malfunctions on the pages **Self-induced** through **Nav** and clears all failures that are not related to weather or misconfigurations.
- **Failed radio stations**: When a station identifier is entered, the respective station fails. Marker beacons fail when the related checkbox is selected.
- The sliders under **Allow random failures within a flight phase** may be used to prepare a *random* failure scenario for a certain flight phase: you can specify the complexity level of a scenario in general, but you cannot exactly foresee when and what failures occur. In addition, by stretching a slider apart, the complexity level itself can be randomized too.

(continued next page)

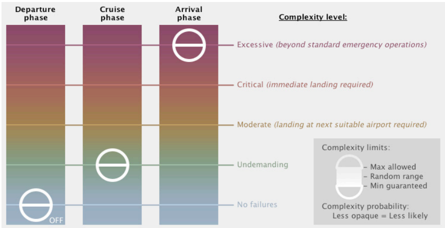
Instructor > Situation > Malfunctions > General: *(continued)*

• **Allow random failures within a flight phase** – Examples:

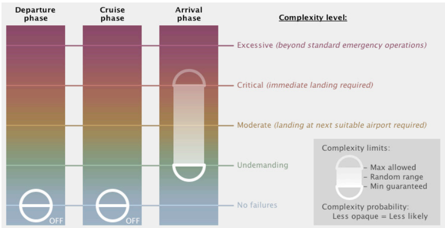
The departure scenario will include a combination of failures that forces the crew to land at the next suitable airport (moderate level). No further random failure scenarios will start during cruise and arrival.



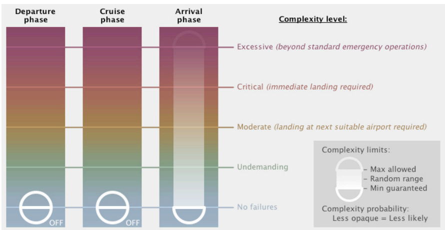
There will be no random failures during the departure. Some minor faults will occur during the cruise (undemanding level). The arrival scenario will be nearly fatal (excessive level); it will be survivable if the crew is well trained.



The complexity level of the arrival scenario is somewhat vague. But the model guarantees the complexity will not rise above the critical level, and will not drop below the undemanding level. The slider transparency gradient also indicates the scenario will *probably* be rather undemanding than critical.

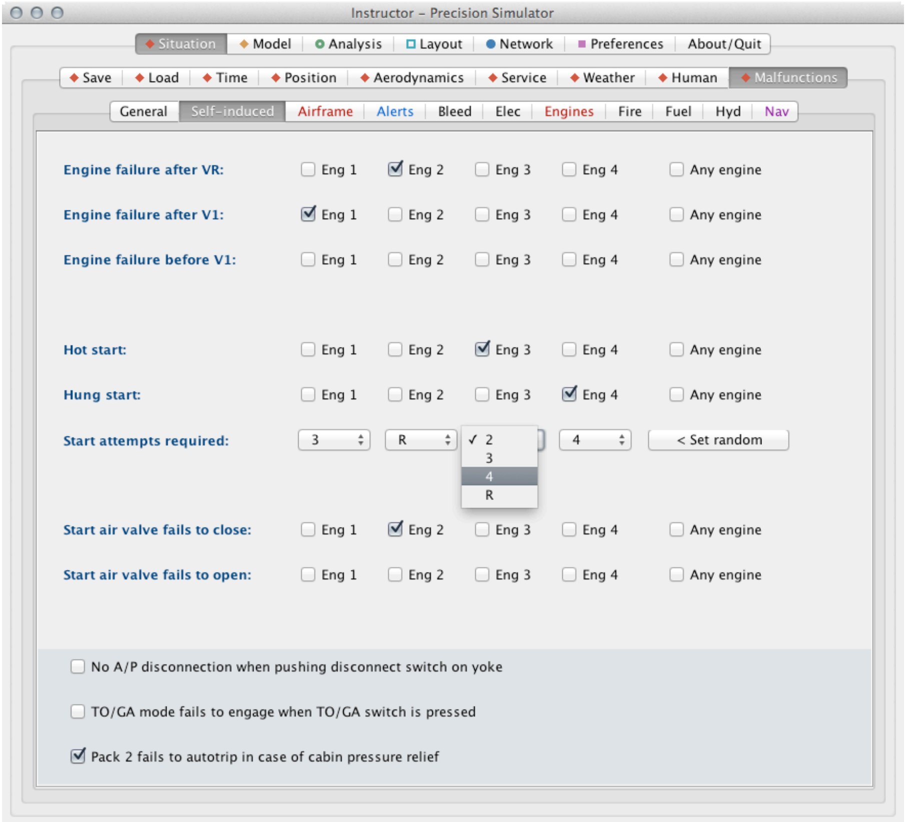


The complexity level of the arrival scenario is highly vague. It may be anywhere between excessive and failure-free. However, the chance of getting a failure-free level is much higher than of getting the excessive level (the upper portion of the slider is very transparent, meaning the upper level is very unlikely).



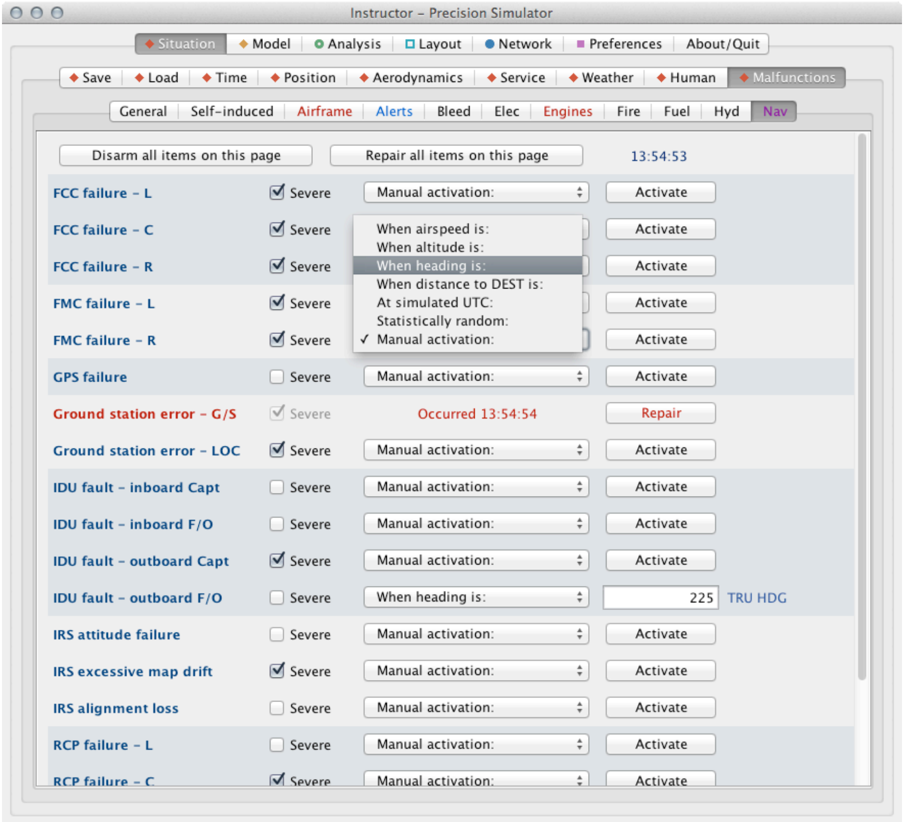
• A black PRESENT flag indicates the present flight phase (see previous page). The departure phase starts when the groundspeed rises above 60 kt, and ends when climbing through 18000 ft. The cruise phase starts thereafter. The arrival phase starts when the aircraft descends through 18000 ft, and ends when the groundspeed is below 50 kt, or when the flap lever is not in the landing range while the aircraft is on the ground. When below 18000 ft, the departure phase will restart when the climb rate is 500 fpm or more for circa 15 seconds; the arrival phase will restart when the descent rate is 500 fpm or more for circa 15 seconds.

Instructor > Situation > Malfunctions > Self-Induced:



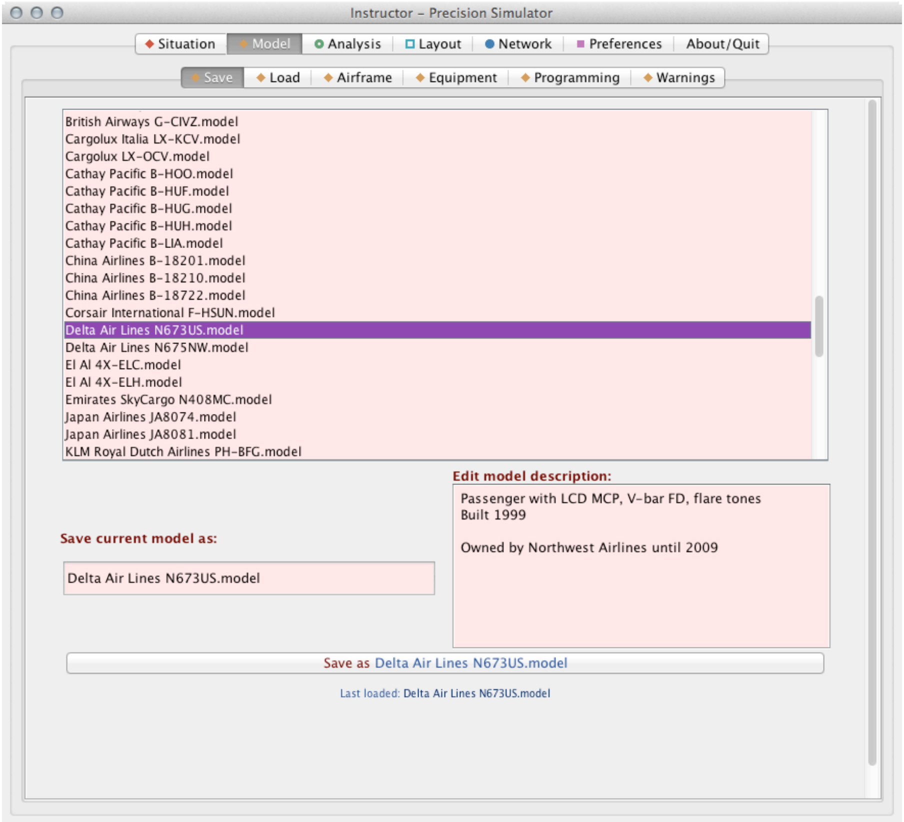
- This page provides checkboxes for arming self-induced malfunctions; for example, a hot start can only occur during *start*, not when reaching a certain altitude or speed and so on.
- **Start attempts required**: Use this feature to determine how many attempts will be required until the selected hot or hung start condition clears itself. Select **R** for a random number. Click the **Set random** button to set **R** in all four columns. A start attempt is considered done when the fuel control on the flight deck is set to CUTOFF for a dry spin during start.
- Note: If you like to set up an instructor screen on a dedicated computer monitor, you may place the Instructor pages in one part of that monitor, and place the circuit breaker panels of the flight deck frame in the remaining free space on that monitor. Through the circuit breaker panels, you have control over hundreds of additional malfunctions which are not listed on the Instructor pages.

Instructor > Situation > Malfunctions > (Category):



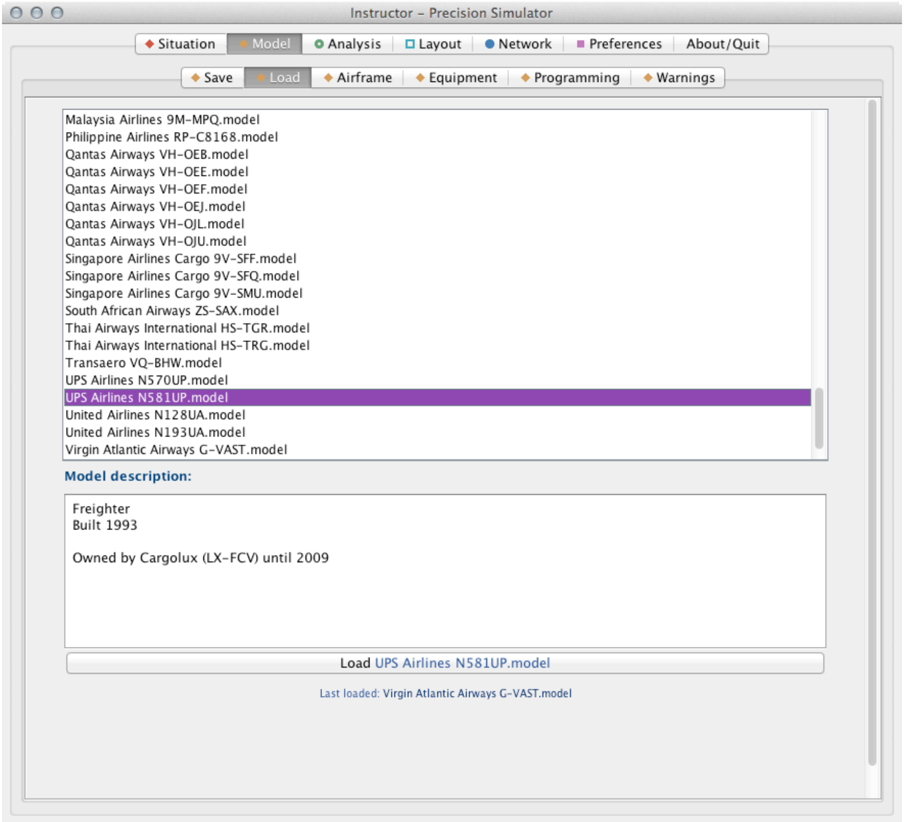
- These pages—**Airframe** through **Nav**—provide for each failure seven different trigger conditions. When a condition other than **Manual activation** is selected, an edit field replaces the **Activate** button. Entries in that edit field are automatically limited, or are denied if the entered format is invalid. For UTC entries—00:08:55, for example—you may type just the six digits 000855. The colons will be inserted when the Enter key is pressed.
- Every malfunction item listed is, in fact, a set of *two* different malfunctions—this actually doubles the amount of failures listed on the Instructor. Each set consists of a severe and a non-severe variant. For instance, a **Gear disagree** fault can be a *Gear-does-not-extend* fault, or a *Gear-does-not-retract* fault. The desired variant is selectable through the associated **Severe** checkbox. Hover the mouse over this checkbox to get a tooltip with a description.
- If more items are listed than can be shown on one page, the page can be scrolled.
- Pages containing any activated malfunction have a red tab title, those containing any armed malfunction have a blue tab title, and those containing both have a magenta tab title.

Instructor > Model > Save:



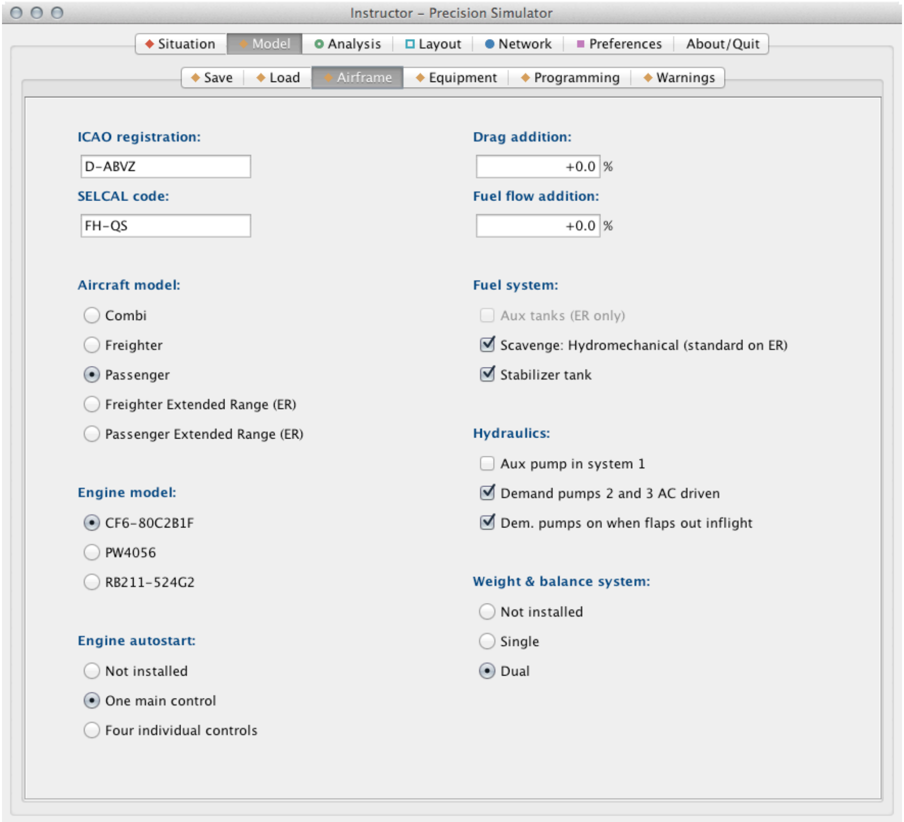
- This page may be used to save all current aircraft model settings and all FMC performance factors settings in an aircraft model file. The current model settings are shown on the pages **Airframe**, **Equipment**, **Programming**, and **Warnings**. The performance factors can be accessed through the CDUs on the flight deck (refer to **PERF FACTORS** in chapter **FMS**).
- The lower right-hand text edit field allows you to add or edit a description. Selecting a file name from the list will not change your description.
- The name of the file to be saved can be edited in the lower left-hand edit field. The simulator will add a *.model* suffix if it is not entered already.
- When the **Save as** button is clicked, the button label changes to **Confirm: Save as**, requiring a second click for confirmation. Only this second click will save the file. When not confirmed within 5 seconds, the button label is reset to **Save as**.
- To delete a file, select the respective file on the list, then press the **Delete** key on the keyboard.

Instructor > Model > Load:



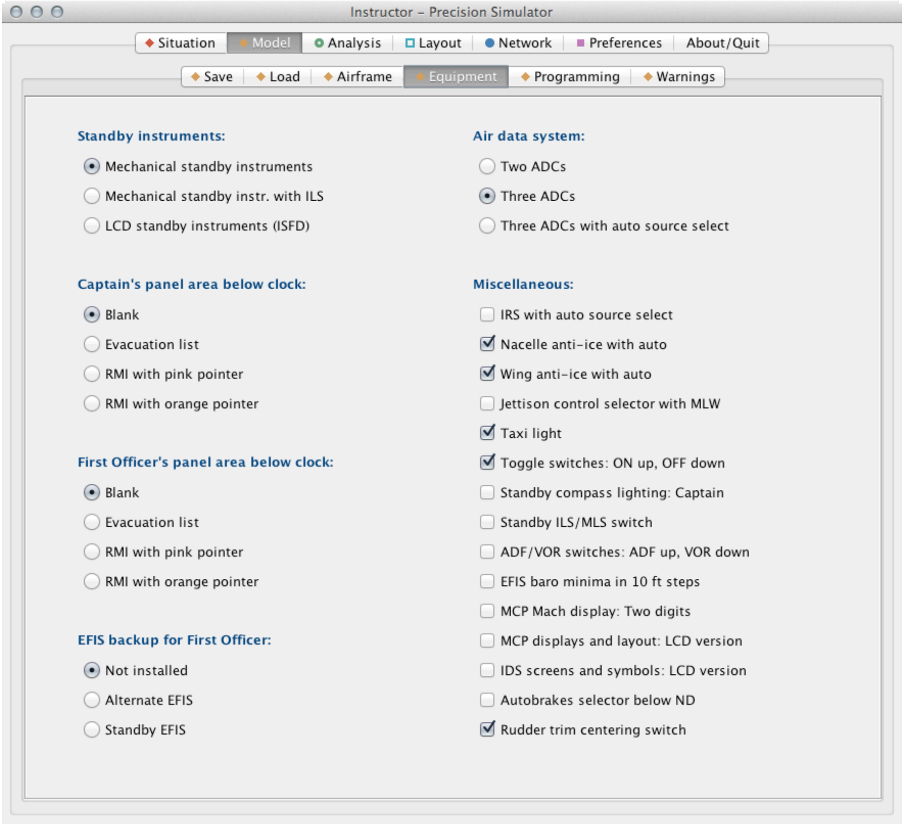
- This page may be used to load an aircraft model file.
- To load a file, double-click the desired file on the list.
- The **Load** (or **Reload**) button may be used as well; it will load the file selected on the list.
- To delete a file, select the respective file on the list, then press the **Delete** key on the keyboard.

Instructor > Model > Airframe:



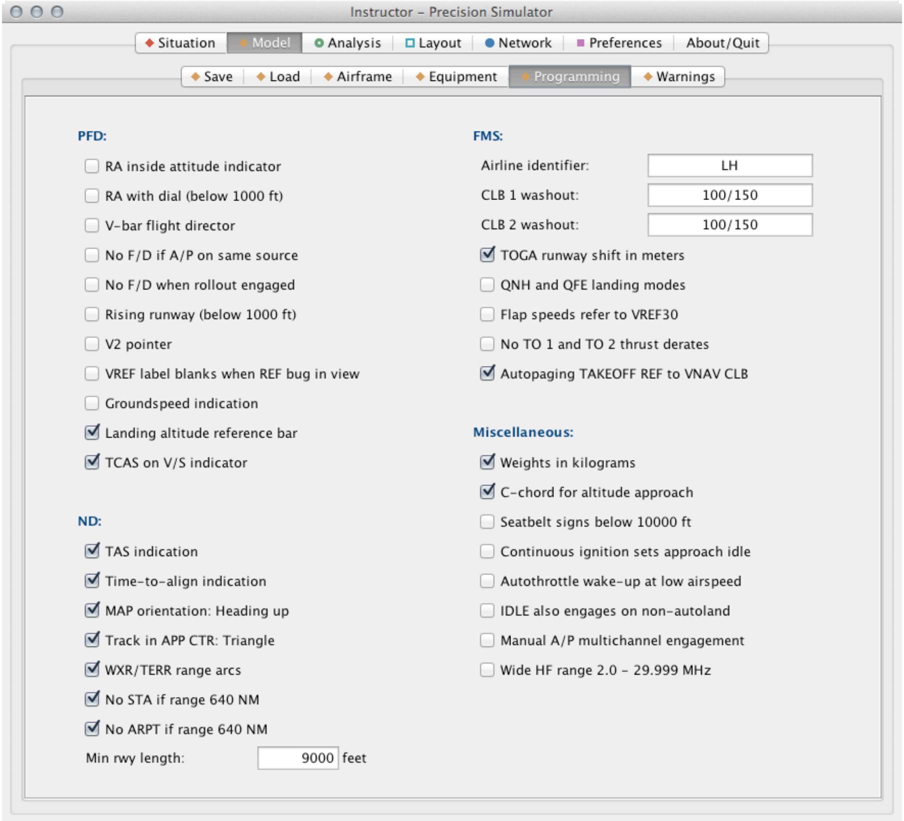
- Note that the engine identifiers displayed on this page are automatically changed when switching between ER and non-ER aircraft models.
- In the edit fields for **Drag** and **Fuel flow** additions, you may enter a comma instead of a period if you use a numeric pad that has a comma key. It will change to a period when the Enter key is pressed.
- Hover the mouse over an object on this page to show tooltips with descriptions.

Instructor > Model > Equipment:



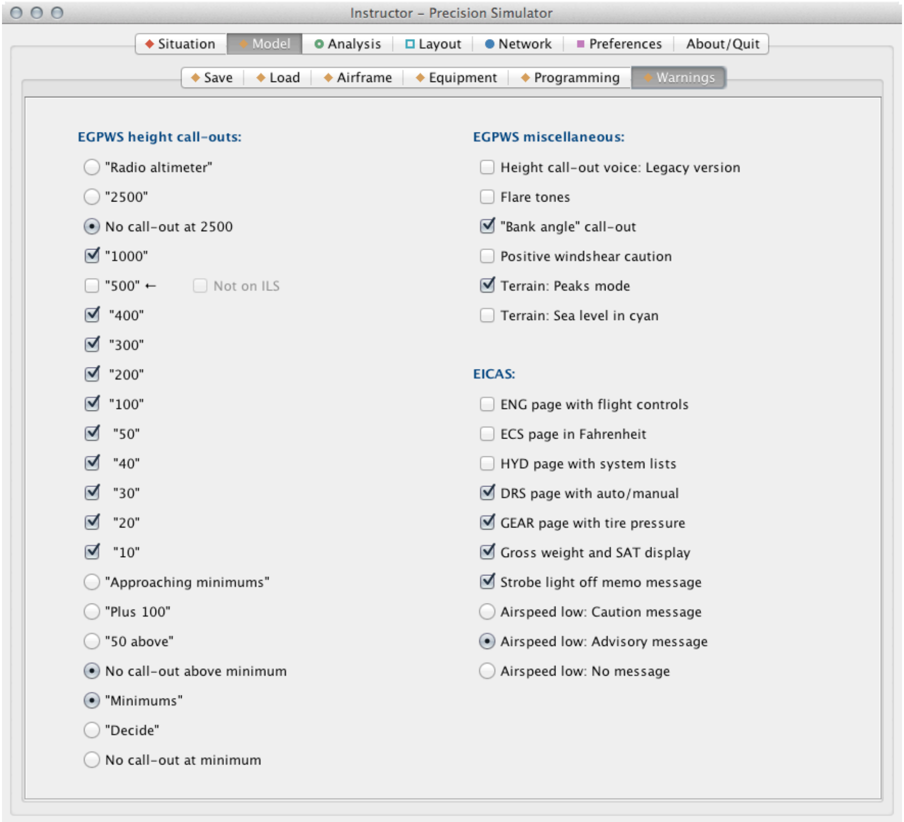
- This page mainly refers to variations of the flight deck panels and switches, and to the associated devices in the equipment compartments.
- Hover the mouse over an object on this page to show tooltips with descriptions.

Instructor > Model > Programming:



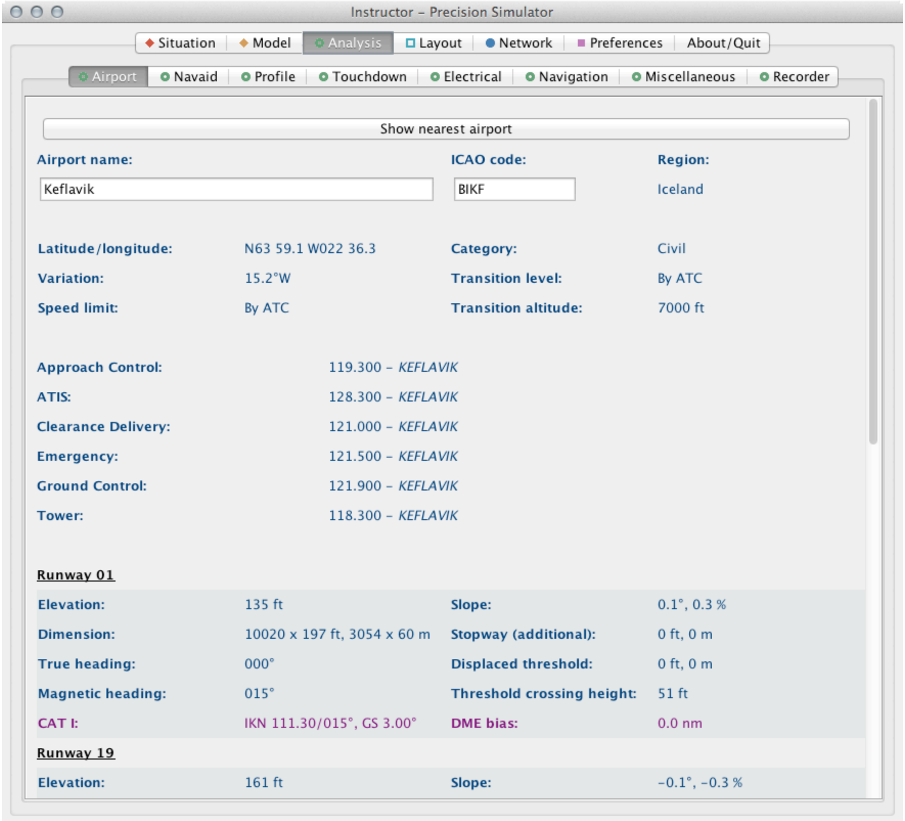
- The options on this page are related to avionics software versions and to pin programming. Pin programming on the real aircraft is a method by which certain electrical pins in an avionic hardware unit are grounded to activate specific options in that unit.
- Hover the mouse over an object on this page to show tooltips with descriptions.

Instructor > Model > Warnings:



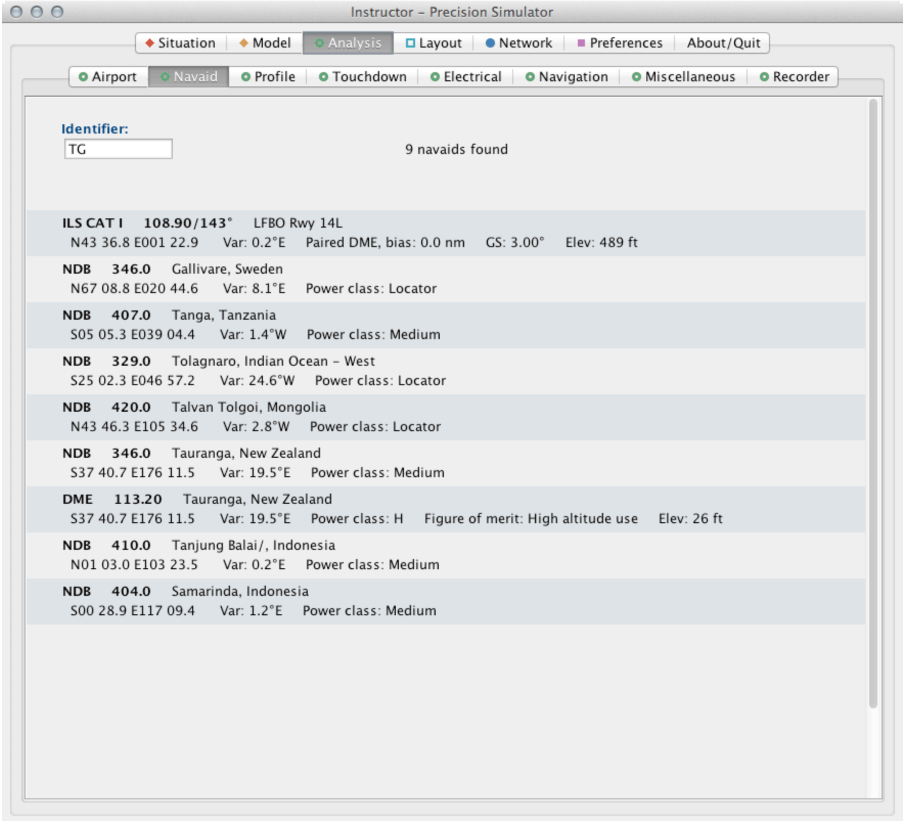
- This page, like the previous one, refers to software versions and to pin programming; however, this page focusses on warning system options in particular (EGPWS stands for Enhanced Ground Proximity Warning System, and the EICAS is the Engine Indication and Crew Alerting System).
- Hover the mouse over an object on this page to show tooltips with descriptions.

Instructor > Analysis > Airport:



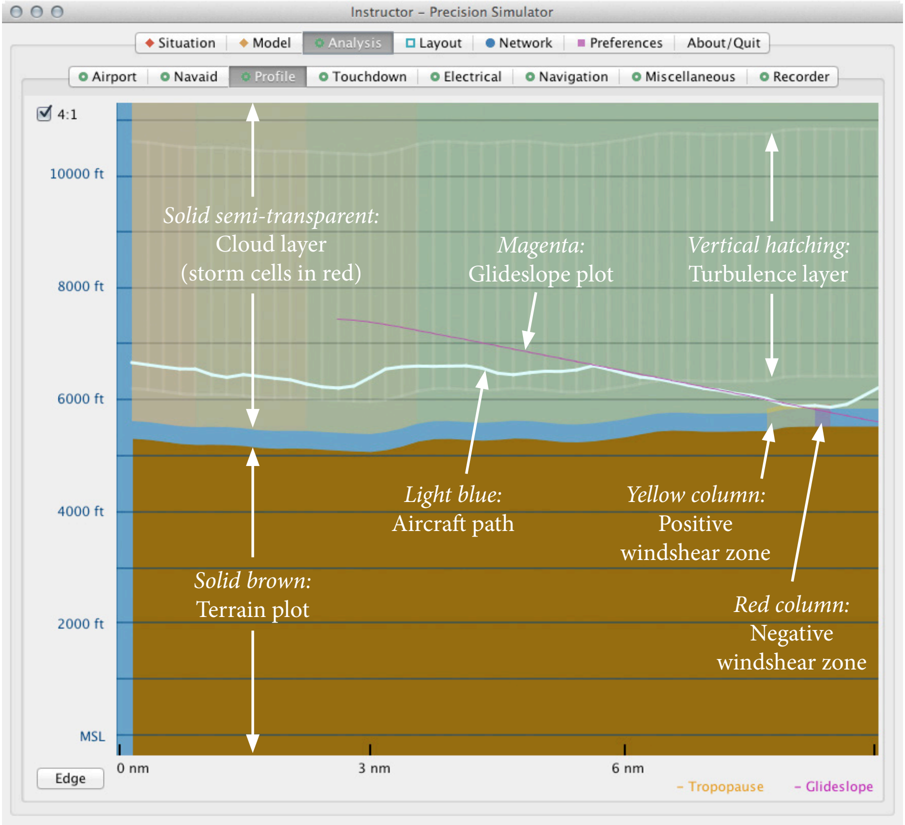
- This page displays information about an airport of your choice. Enter an airport ICAO code, or enter the initial unique characters of an airport name. The database contains the airport names as provided by the respective governments; there may be inconsistencies in some cases (like, city name included or excluded, or spaces filled by dashes or slashes).
- The button **Show nearest airport** refers to the distance from the current aircraft position.
- If more data are provided than can be shown on one page, the page can be scrolled. If gate identifiers and coordinates are published for the airport, gate identifiers are displayed at the bottom of the page.

Instructor > Analysis > Navaid:



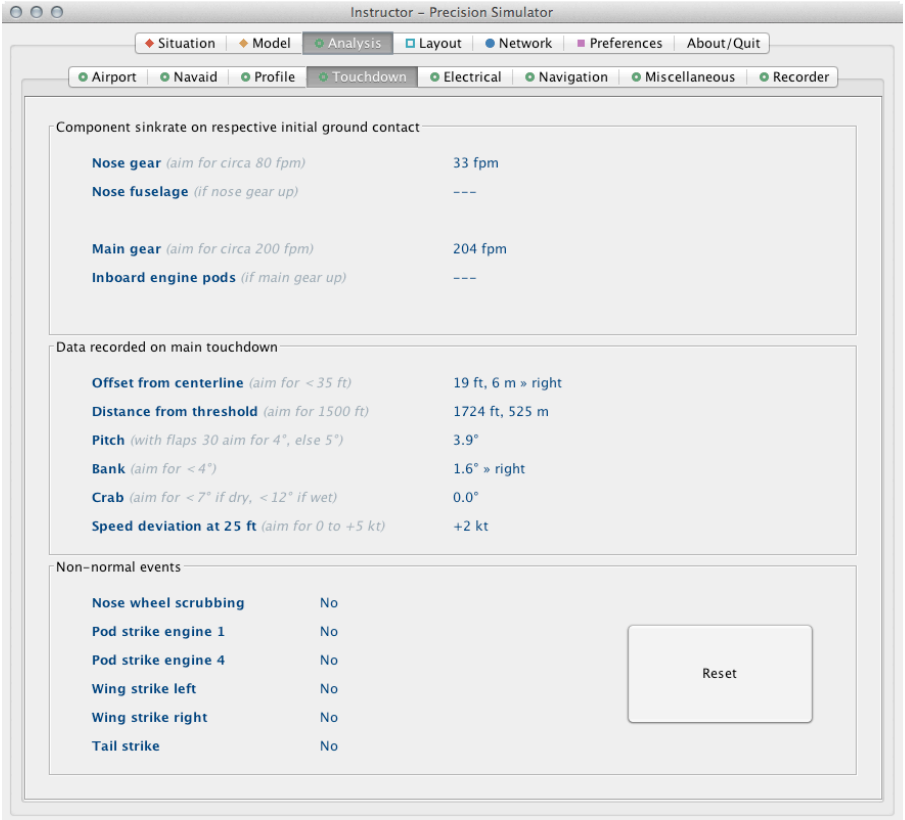
• Enter the identifier of any VOR, DME, NDB, localizer, or ILS to display the respective information stored in the database.

Instructor > Analysis > Profile:



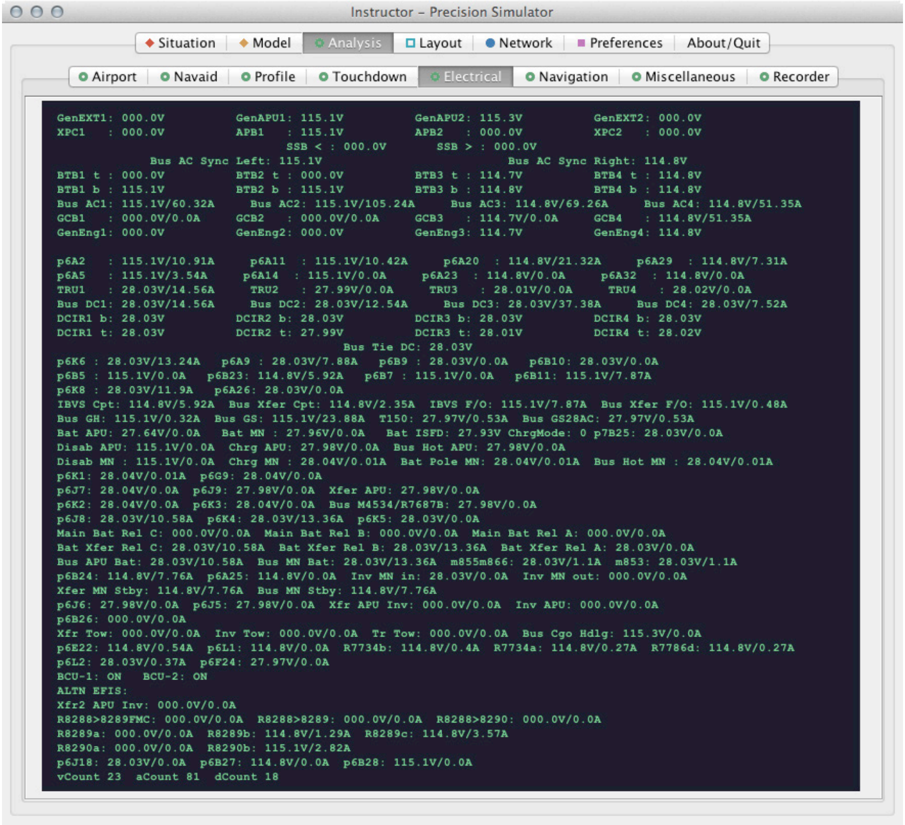
- Glideslope, terrain, and all other features, are plotted along the *aircraft track*; this page does not necessarily represent a straight cross section through the earth. For example, when the aircraft track follows a circle, the glideslope *plot* will rise and fall; or, for instance, a certain hill may appear multiple times in a row.
- The plot comprises the last 9 nm flown when the time acceleration on **Instructor** > **Situation** > **Time** is set to factor 1. When a different factor is set, the x-axis is accordingly factored as well.
- When the checkbox **4:1** is not selected, the vertical scale ranges to 45000 ft, and the ratio of the x-axis to the y-axis is 1:1 (if the time acceleration factor is 1).
- The **Edge** button scrolls the current plot position to the right-hand edge of the display.
- The orange tropopause line (not visible in the example above) indicates *average* values; it does not show jet stream related details.

Instructor > Analysis > Touchdown:



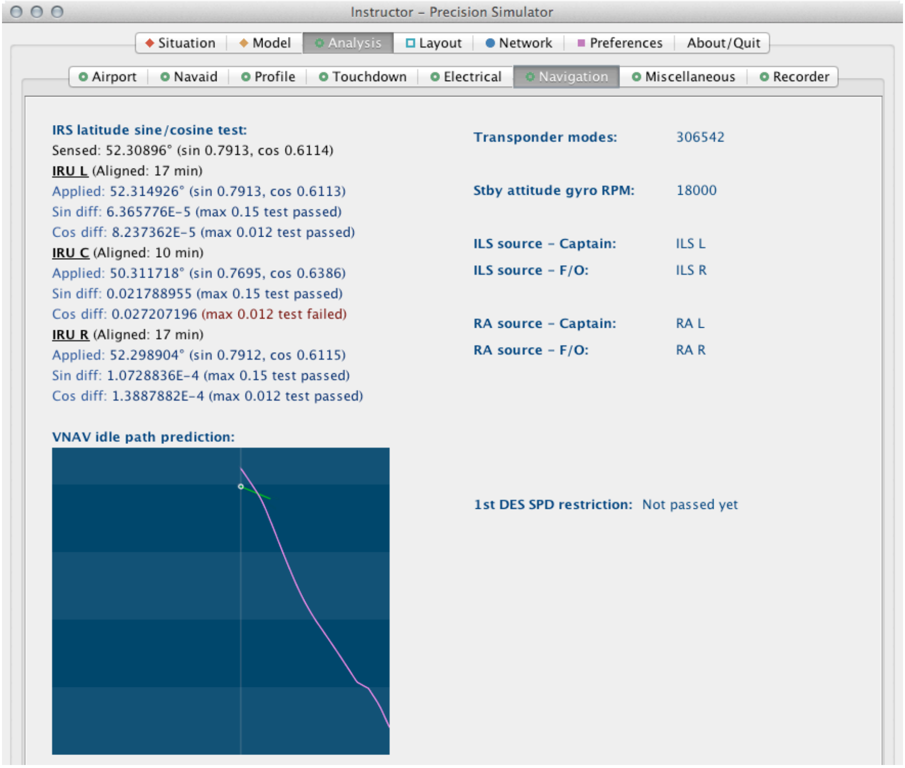
- This page indicates training relevant data recorded during the last landing; it also includes some recommendations (shown in italic font).
- The recommended threshold distance of approximately 1500 ft refers to *manual* landings; *autoland* typically aims for circa 2500 ft.
- The recommended pitch of 4° with flaps 30 (5° with flaps 25) refers to the target pitch at the end of the flare process; that is, when the flare is started, rotate *slowly* to that target pitch. Note that these pitch values refer to the attitude indicator, not to the attitude relative to the runway slope. If a runway has a significant slope (indicated on **Instructor** > **Analysis** > **Airport**), add that slope to the target pitch; for example, for a flap 30 landing on a -0.3° downhill runway, aim for 3.7° on the attitude indicator.
- The section **Non-normal events** is active as long as the aircraft is on the ground; therefore, it also indicates nose wheel scrubbing during taxi and tailstrikes on liftoff. This section will be reset when a situation file is loaded or when the **Reset** button is clicked.

Instructor > Analysis > Electrical:



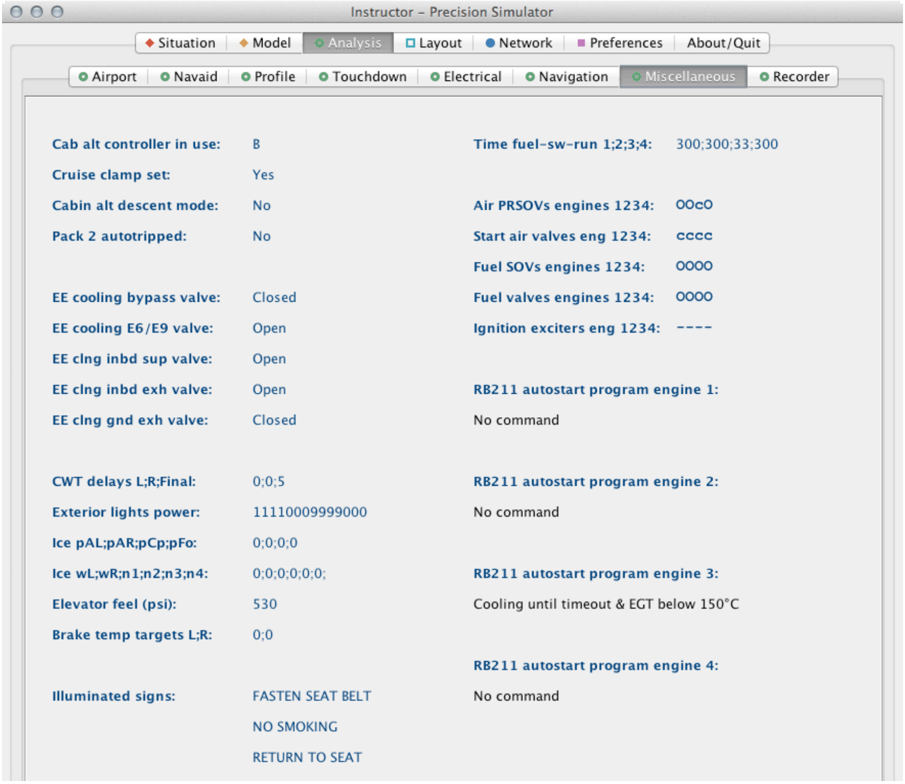
- This page was originally intended for use as a debugging tool during the development of the simulator. The abbreviations are not documented in this book. This page is still included in order to provide an informational background for discussions with avionics engineers.

Instructor > Analysis > Navigation:



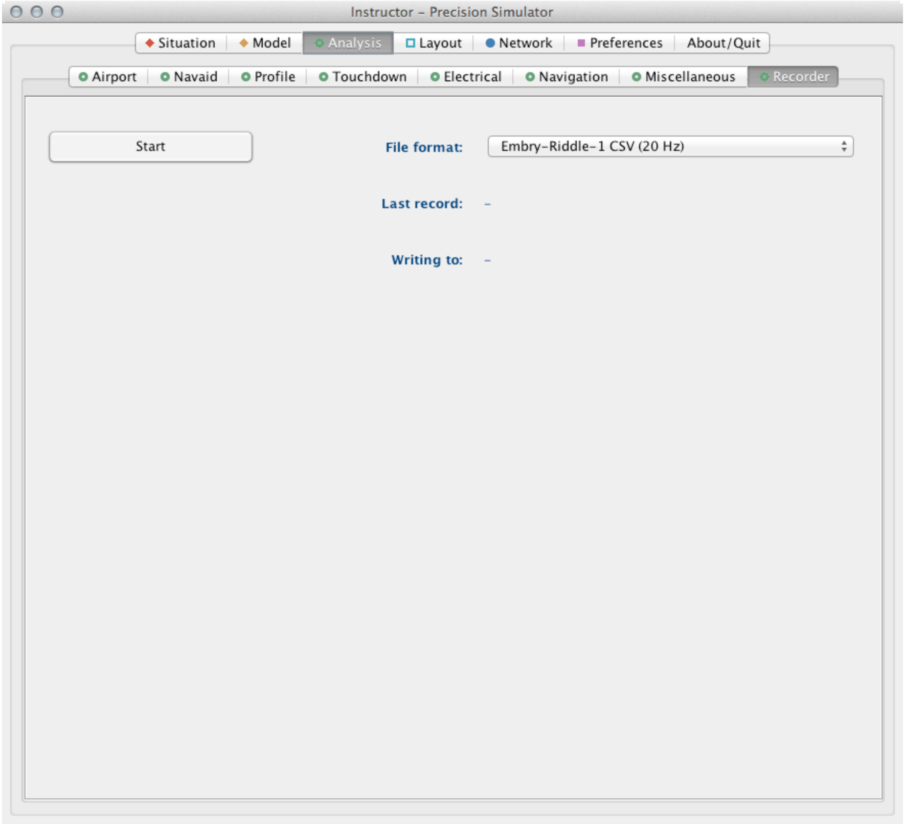
- **IRS latitude sine/cosine test**: During IRS alignment, when the crew has entered the present position data in the FMS, the system checks the angle differences between the entered latitude and the IRU sensed latitudes. If an angle difference exceeds a certain sine or cosine value, the FMC message ENTER IRS POS will be shown. That message may also appear due to other effects. But if it occurs because of a failed sine/cosine test, "test failed" will be indicated in red on the above page. It can then be concluded that the crew entry is incorrect or a sensor system failure exists in the respective IRU.
- **VNAV idle path prediction** shows the planned idle thrust descent path from the T/D to the first hard altitude constraint. The path is shaped by the FMC descent forecast data, the airspeed schedule, and the resultant groundspeed variations along the route. The small circle indicates the aircraft position. The green line shows the aircraft's vertical motion trend.
- **Transponder modes**: Refer to **ATC Transponder System** in chapter **Navigation Systems**.
- **Stby attitude gyro RPM** relates to the gyro in the mechanical standby attitude indicator.
- **ILS & RA sources**: Refer to **Instrument Source Selection** in chapter **Flight Instruments**.
- **1st DES SPD restriction** shows whether the first FMC descent speed restriction is passed.

Instructor > Analysis > Miscellaneous:



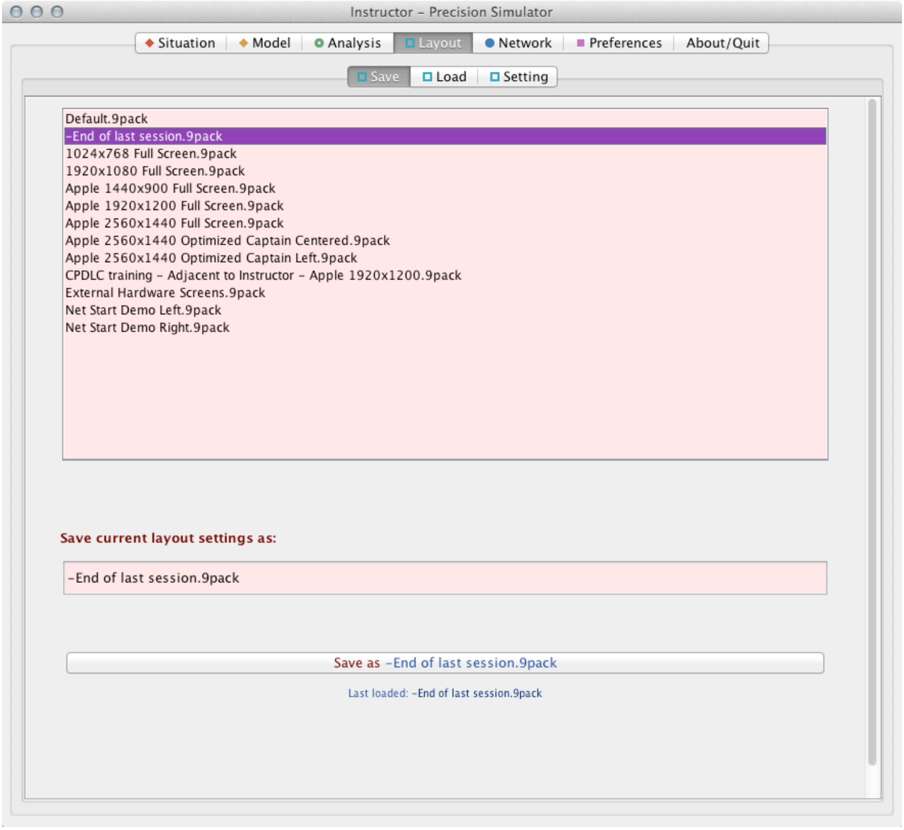
- The upper left-hand quarter of this page relates to the cabin pressurization system and to the air valves of the electrical equipment (EE) cooling system.
- **CWT delays**: Shows the minutes of two 5-minute timers related to the left and right center tank pump pressures and of a final delay which are used in the fuel scavenge control logic; an asterisk * indicates the respective timer is running.
- **Exterior lights power**: Refer to **Exterior Lighting Controls** in chapter **Aircraft General**.
- **Ice**: Refer to chapter **Ice & Rain Protection**.
- **Elevator feel**: Refer to **Elevator Control** in chapter **Flight Controls General**.
- **Brake temp targets L;R** indicates the actual highest wheel brake temperatures left and right of the aircraft centerline; it may take some minutes until the heat is distributed to the brake temperature sensors whose measurements are displayed on the EICAS gear synoptics.
- **Illuminated signs** indicates which passengers signs are currently illuminated.
- For the details on the right-hand side of this page refer to chapter **Power Plant**.

Instructor > Analysis > Recorder:



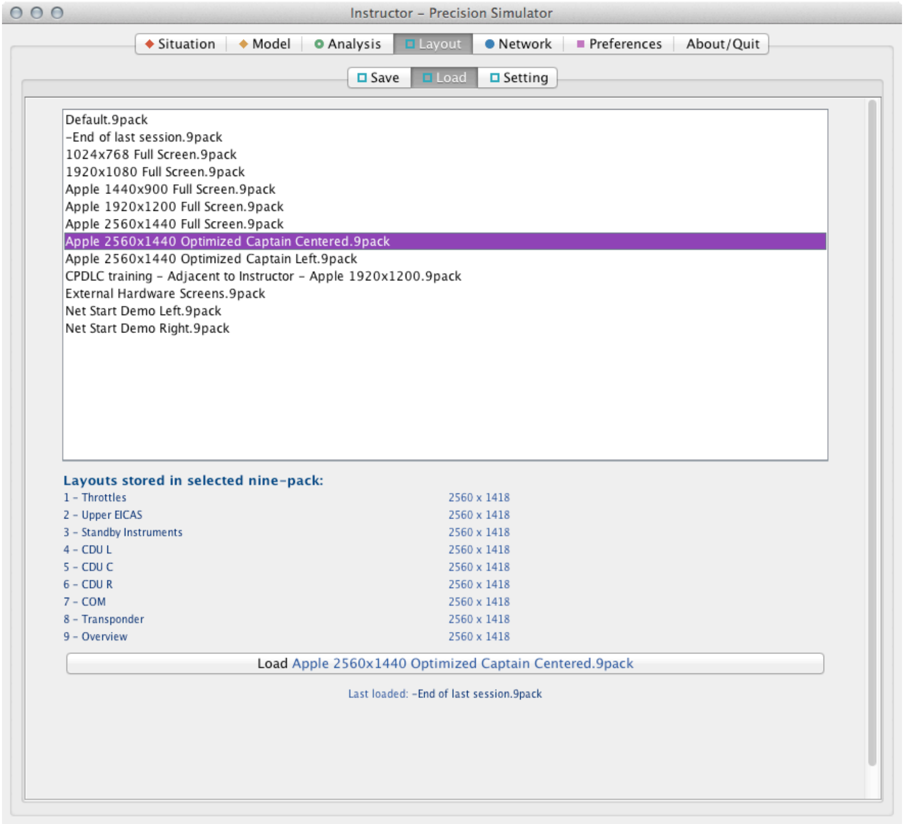
- This function is for academic purposes. It consumes some computer resources; do not use this function if you do not need it.
- Clicking the **Start** button creates a new file in the folder *Aerowinx/Logs* and starts a customer specific data stream which will be recorded in that new file. Clicking the button a second time stops the recording. The recording time is limited to 20 hours per file.

Instructor > Layout > Save:



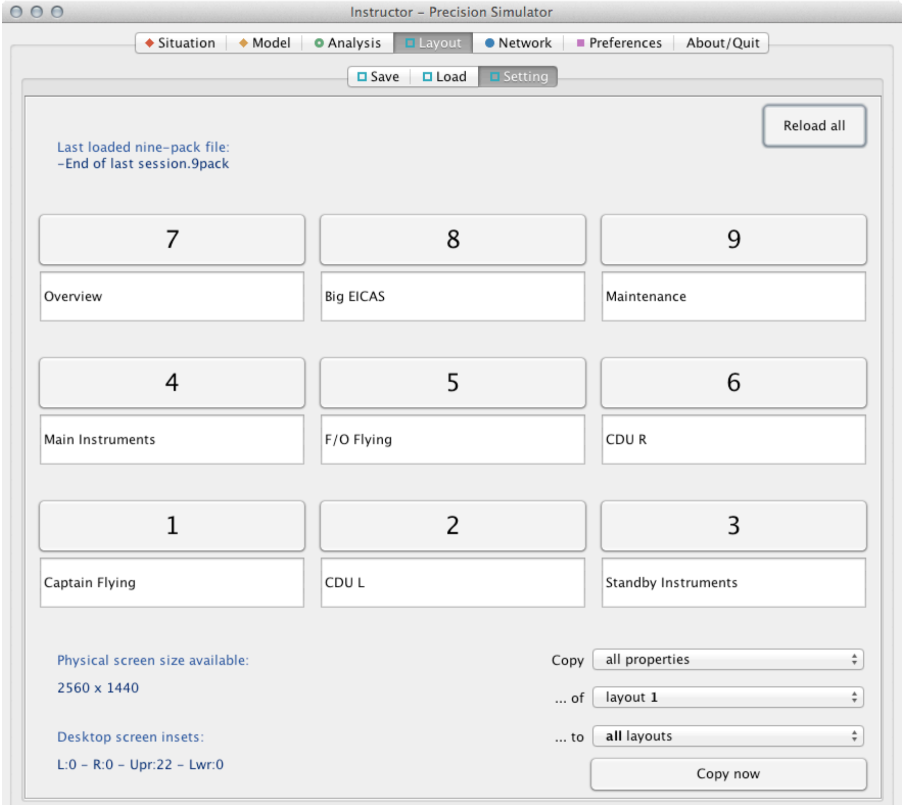
- This page may be used to save the current nine layout settings in a single 9-pack file.
- The name of the file to be saved can be edited in the lower edit field. The simulator will add a *.9pack* suffix if it is not entered already.
- When the **Save as** button is clicked, the button label changes to **Confirm: Save as**, requiring a second click for confirmation. Only this second click will save the file. When not confirmed within 5 seconds, the button label is reset to **Save as**.
- To delete a file, select the respective file on the list, then press the **Delete** key on the keyboard. *Default.9pack* cannot be deleted.

Instructor > Layout > Load:



- This page may be used to load a layout 9-pack file.
- To load a file, double-click the desired file on the list.
- The **Load** (or **Reload**) button may be used as well; it will load the file selected on the list.
- To delete a file, select the respective file on the list, then press the **Delete** key on the keyboard. *Default.9pack* cannot be deleted.

Instructor > Layout > Setting:



- Here you can enter frame titles for each of the nine layouts. To show the desired layout, push the related numeric button on this page or on your keyboard's numeric pad. Layouts can also be selected by USB buttons (refer to **Instructor** > **Preferences** > **USB**).
- The button **Reload all** reloads the last loaded layout 9-pack file.
- The button **Copy now** copies certain properties from one layout to another. For example, from the "*Copy*" combo box select **all properties**; from the "*... of*" combo box select **layout 1**; and from the "*... to*" combo box select **layout 2**. Then press **Copy now**. Layout 2 is now identical to layout 1. This feature may be used to prepare some common settings; certain details in each layout may then be modified manually.
- Divider settings are stored by percentage values relative to the flight deck frame size. For instance, when the flight deck is divided in the middle, the divider is stored by the value 0.5; this means, when the flight deck frame is resized, the divider remains in the middle (until you drag the divider to a different position).

(continued next page)

Instructor > Layout > Setting: *(continued)*

When designing your personal layouts, consider the following notes to optimize your graphic performance on slow computers

+ The most performance-hungry flight deck areas are the PFDs, NDs, thrust levers, and the windshield. The more they are zoomed in, the lower becomes the frame rate (on slow computers). The frame rate may decrease also when clones of them are shown in other subframes.
+ For this reason, be sure that clones which are not really needed in other subframes, are *completely* outside that subframe. For example, if you have two subframes, with the left one showing a complete real-size ND, and the right one showing a gear lever and a *fraction* of an ND, pan this right subframe so that this *fraction* of an ND is completely out of view.
+ If you want to display just a certain small flight deck area on a monitor in your hardware panel mockup—the captain's PFD and ND, for example—and this area is smaller than your physical monitor, make the entire *flight deck frame* as small as the area you really need, and set your OS X or Windows desktop to solid black. The flight deck frame decoration can be removed on **Instructor** > **Preferences** > **Basics**. Do not delete the simulator's flight deck image files, it may disturb the simulator's graphic system.

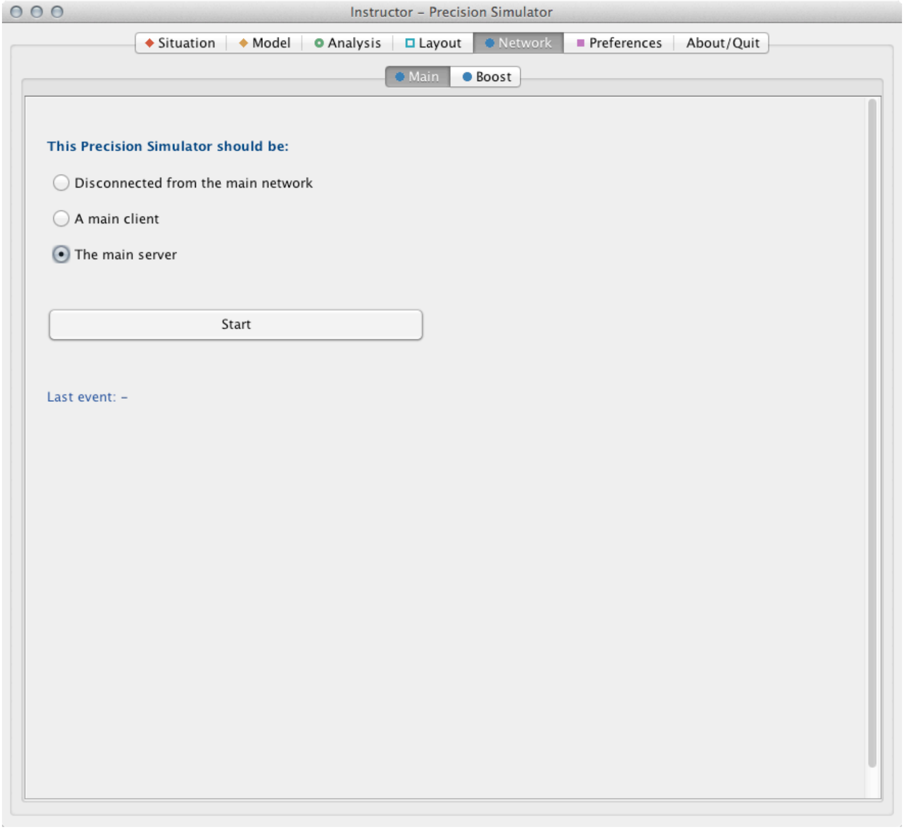
General notes

+ When you use just *one* ND, deactivate the WXR and TERR modes on the other ND. This is not because of the graphics (the other ND is out of view anyway if you follow the advice above), it is because of the *terrain database scanner* continuously running in the background to provide radar ground clutter images or EGPWS terrain images to *two* individual NDs—each ND has its individual range setting and its individual position reference (IRS map shift is possible). The scanner has 50% less work to do when the WXR or TERR mode is selected on just *one* ND. Therefore, select these modes on both NDs only when you actually use both NDs.
+ Another performance-hungry feature within the ND is the WPT mode. Some regions are filled with a large amount of waypoints. Deselect the WPT mode when it is not needed.
+ Microsoft Windows users should check that the Windows task bar at the bottom does not overlap the flight deck frame; otherwise, the frame rate may drop by 90%.
+ Anti-virus, Defender, and other programs running in the background may drastically decrease the frame rate.
+ On notebooks, the battery power saving mode has a great impact on the frame rate. If possible, do not use battery power when running the simulator.

OS X note

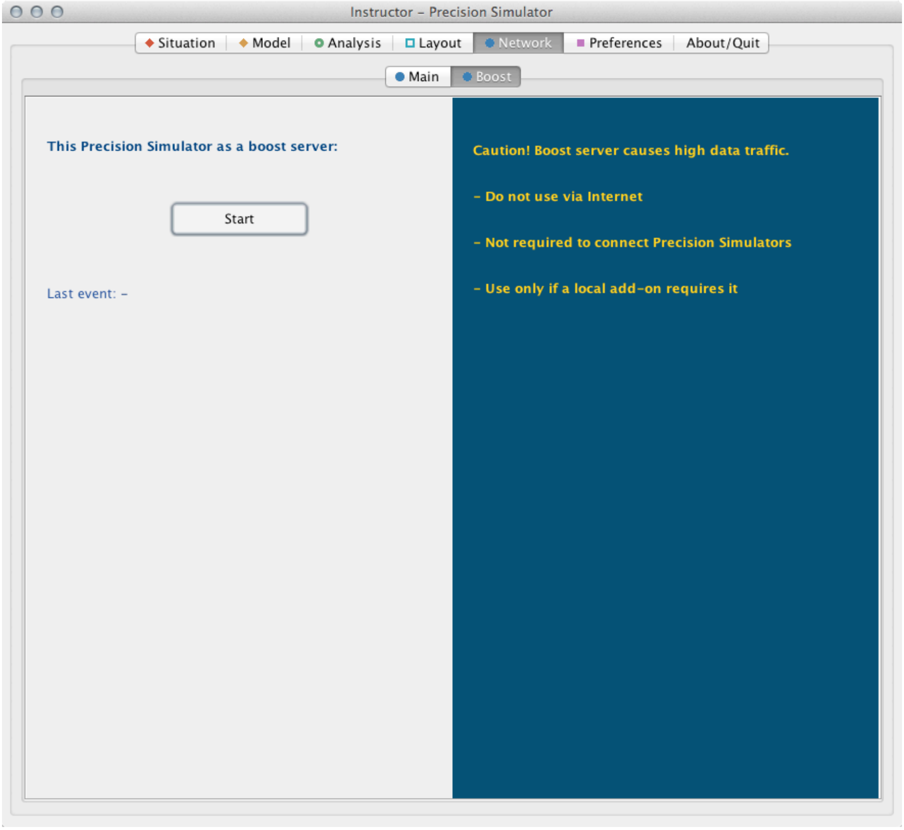
+ You may hide the flight deck frame by pressing CMD + H. However, when the frame is restored, and the dock is in "hidden" mode, OS X will offset the restored frame by a few pixels, showing a small gap at the desktop edge where the hidden dock is located. To correct this offset, just reload the last layout file by pushing the Zero key on the numeric pad or the **Reload all** button on the **Setting** page.

Instructor > Network > Main:



- The main network is used to connect multiple Precision Simulators with each other; this will synchronize the situational data and model data across all connected Precision Simulators. The main network may also be used to connect third-party add-ons to the simulator.
- A multicomputer network requires the computers being connected through ethernet cables (Wi-Fi is not recommended). If more than two computers are used, an ethernet switch is required. Each client must be assigned to the respective server's host address; the address consists of certain numbers and can be checked and entered on **Instructor** > **Preferences** > **Basics**. A network can also consist of multiple Precision Simulators running on a *single* computer; in this case, the host address reads *localhost*.
- To start a network, go to one Precision Simulator, select **The main server**, and push the **Start** button. Then, on each other Precision Simulator, select **A main client** and push the associated **Start** button. There can be multiple clients, but only one server. Every client connects to the same server. A third-party add-on acts like a Precision Simulator client.

Instructor > Network > Boost:

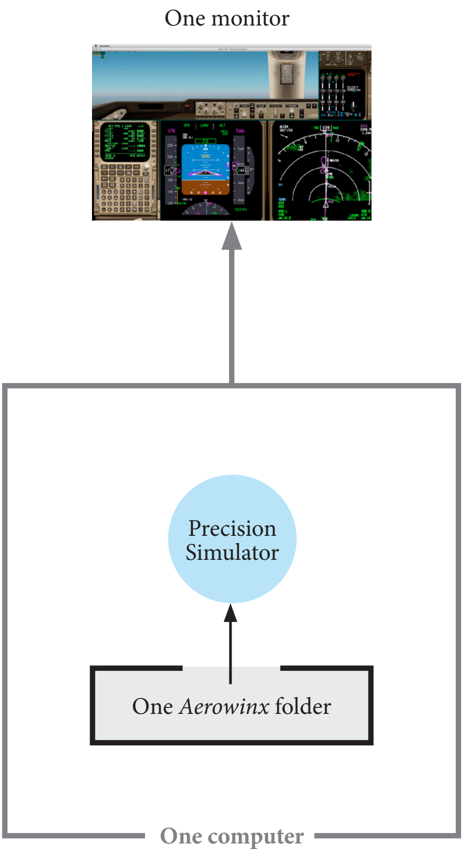


- The boost server is an extra service for special add-ons that need attitude and position data updates at high speed. Such add-ons drive external scenery generators, for example, or feed motion platform systems. Start a boost server only if a local add-on requires it. Refer to the respective add-on documentation.
- The boost server is independent of the main network. The main server and every Precision Simulator client can additionally act as a boost server.

Network Examples:

Example 1

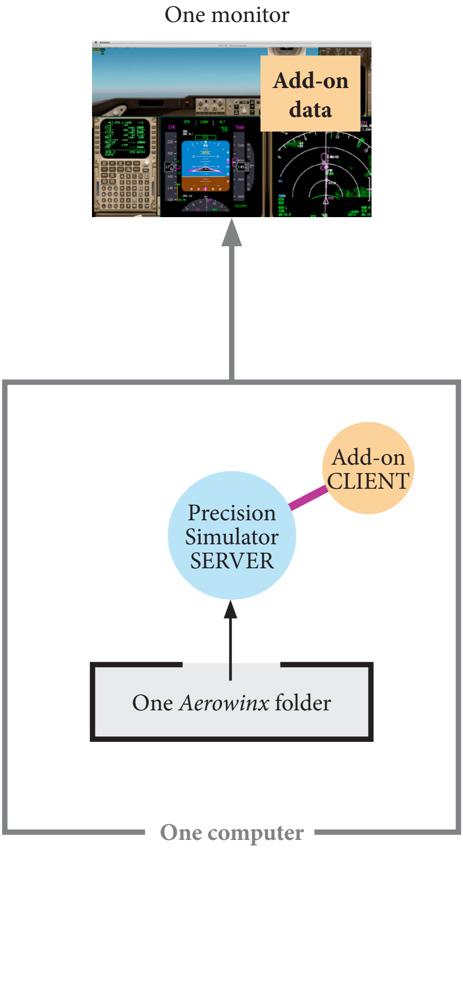
No network is in use. One Precision Simulator is started from the *Aerowinx* folder.



Network Examples:

Example 2

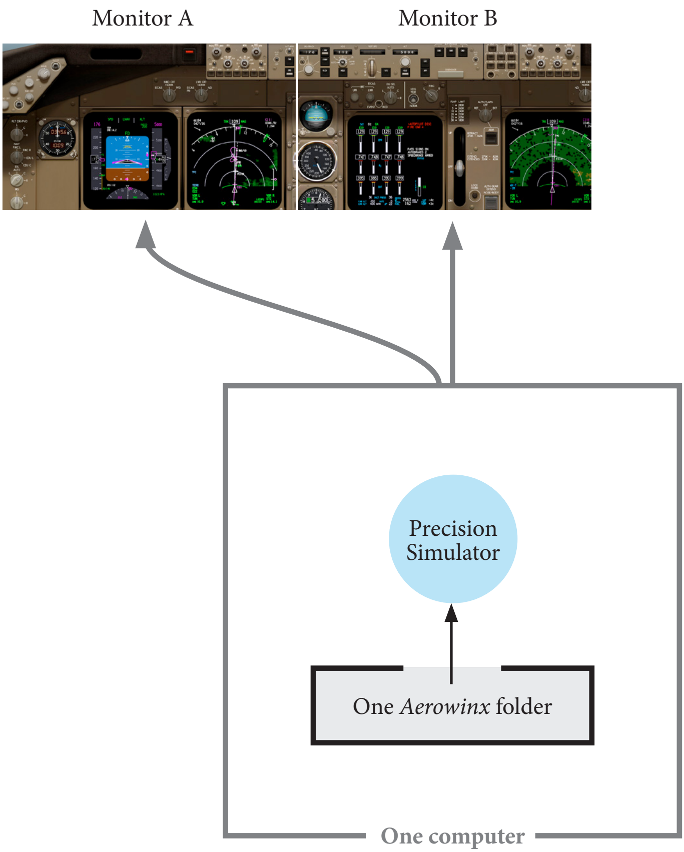
One Precision Simulator is in use; it is also the main server, and an add-on is networked with it. One monitor can show Precision Simulator's flight deck frame and the data of the add-on.



Network Examples:

Example 3

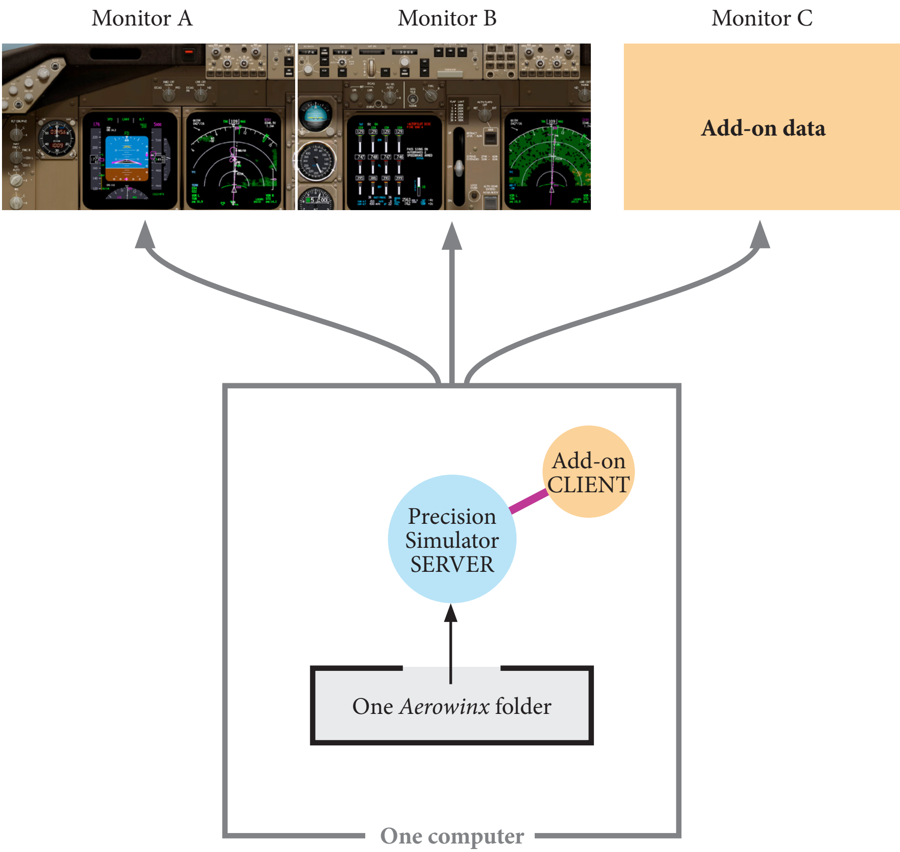
No network is in use. One graphic card feeds two monitors. One Precision Simulator provides one flight deck frame which is stretched across two monitors.



Network Examples:

Example 4

One graphic card feeds three monitors. One Precision Simulator provides one flight deck frame which is stretched across two monitors. That one Precision Simulator is also the main server and is networked with an add-on whose data is shown on the third monitor.

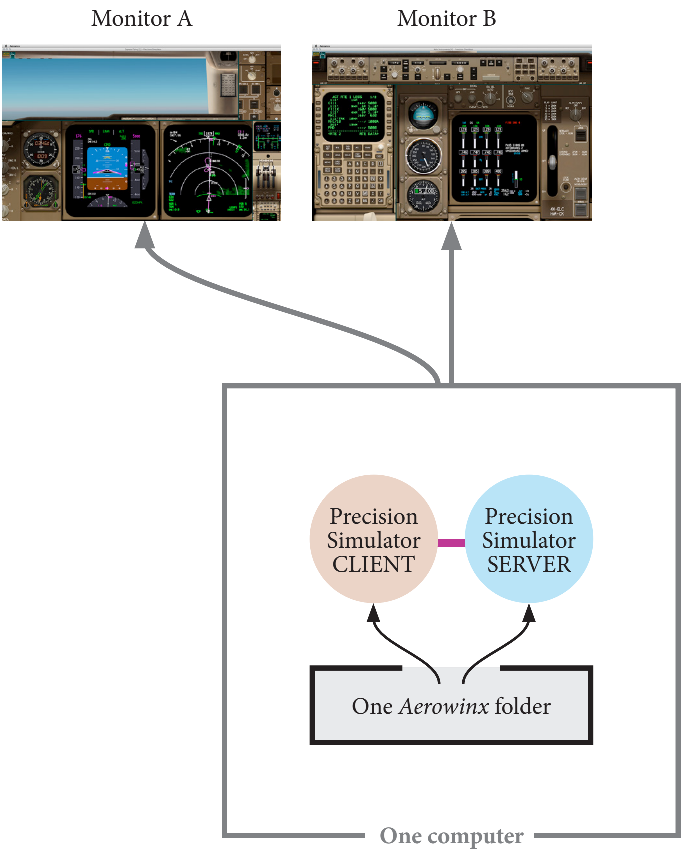


networked

Network Examples:

Example 5

One graphic card feeds two monitors. Two Precision Simulators provide two flight deck frames. Each flight deck frame uses its own layout; one flight deck frame is placed on monitor A, the other on monitor B.

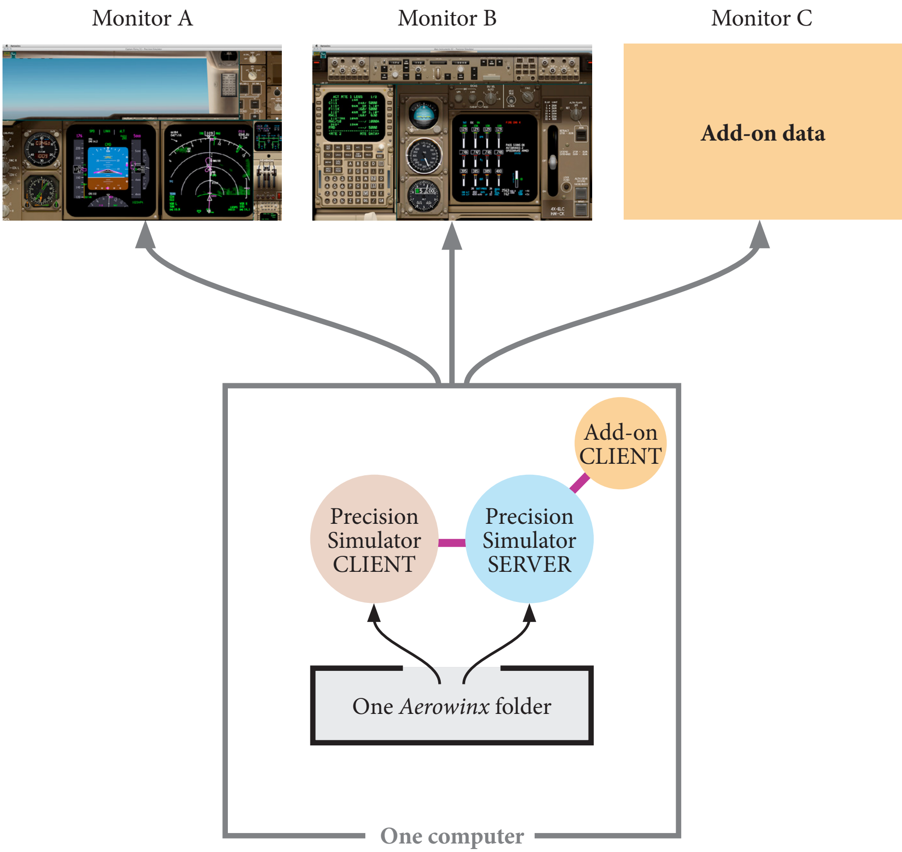


networked

Network Examples:

Example 6

One graphic card feeds three monitors. Two Precision Simulators provide two flight deck frames. Each flight deck frame uses its own layout; one flight deck frame is placed on monitor A, the other on monitor B. The main server is networked with an add-on whose data is shown on monitor C.

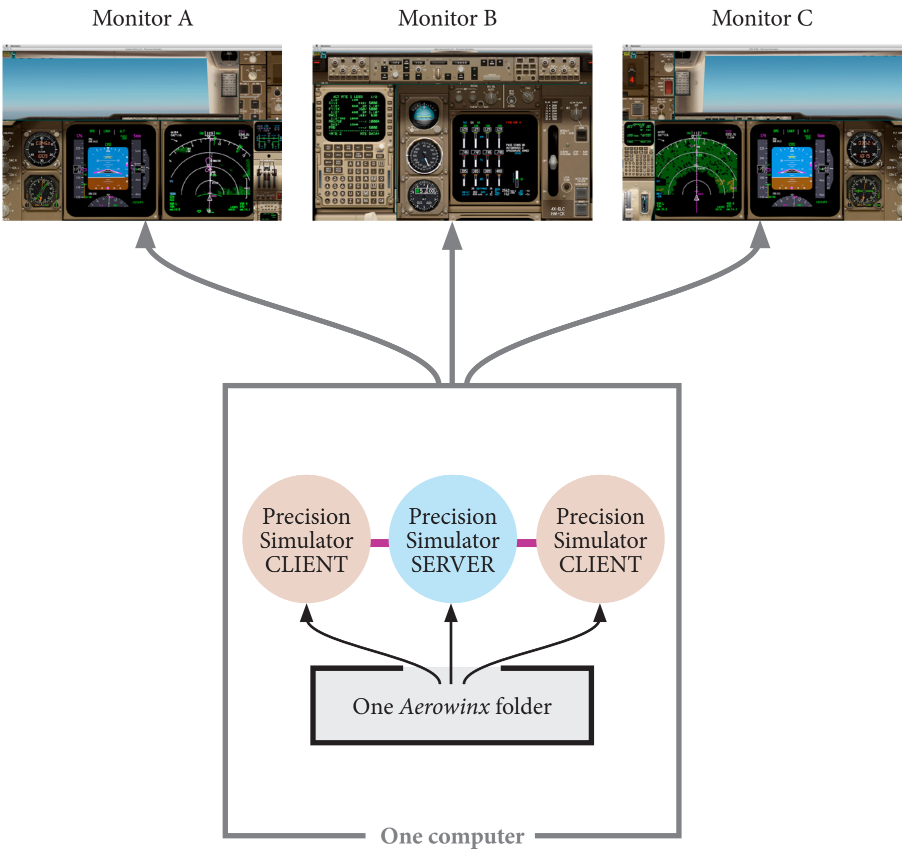


networked

Network Examples:

Example 7

One graphic card feeds three monitors. Three Precision Simulators provide three flight deck frames. Each flight deck frame uses its own layout, and each is placed on a separate monitor.

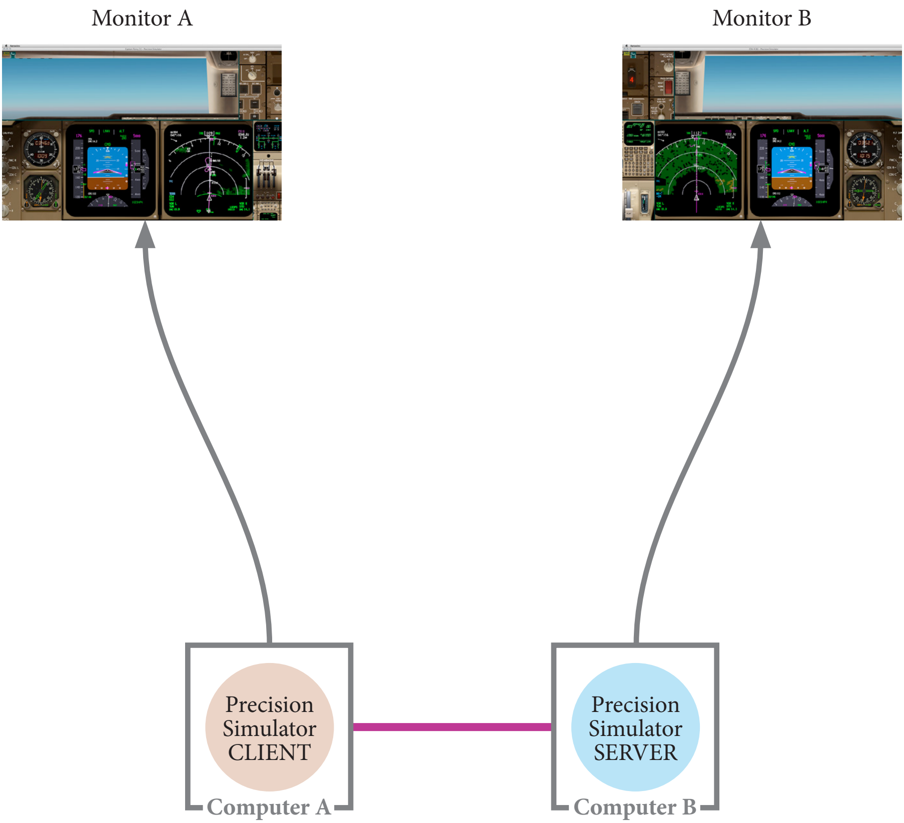


networked

Network Examples:

Example 8

Two Precision Simulators on two computers provide two flight deck frames to two monitors. The two computers may be connected directly through an ethernet cable, or may be connected via Internet.

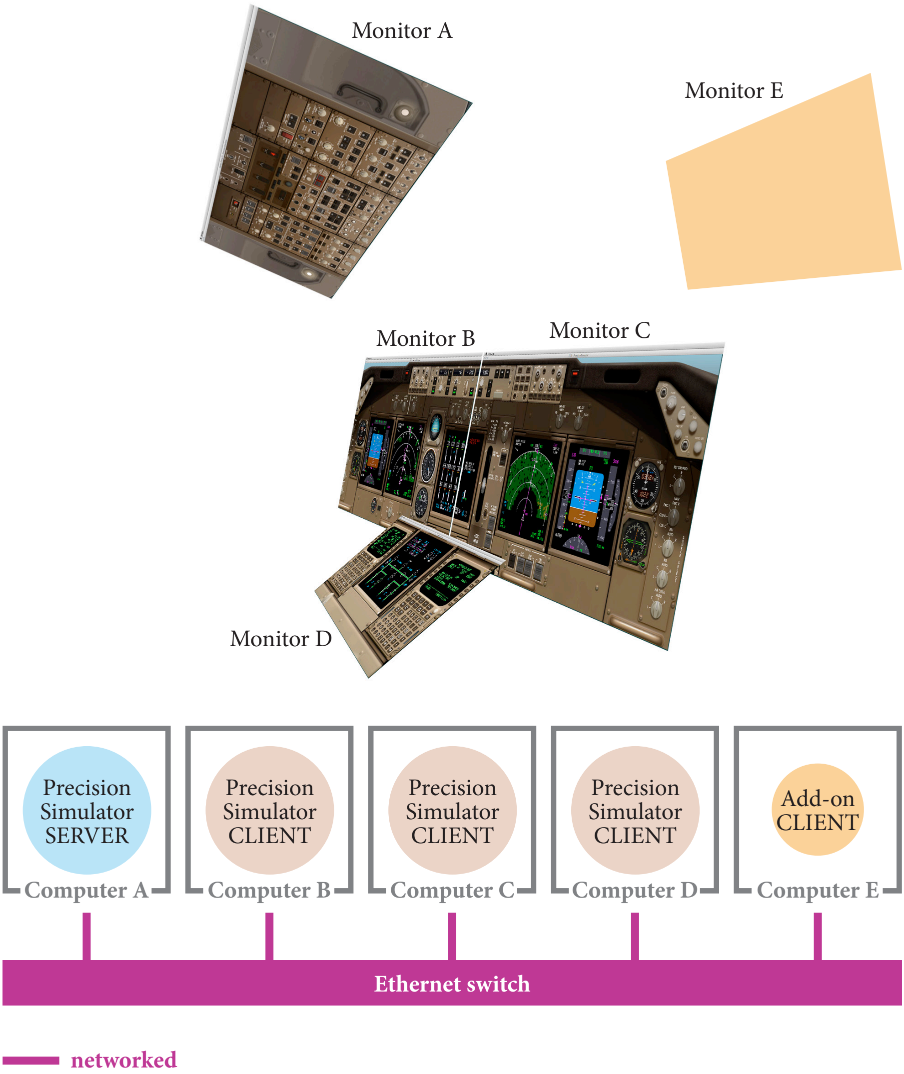


networked

Network Examples:

Example 9

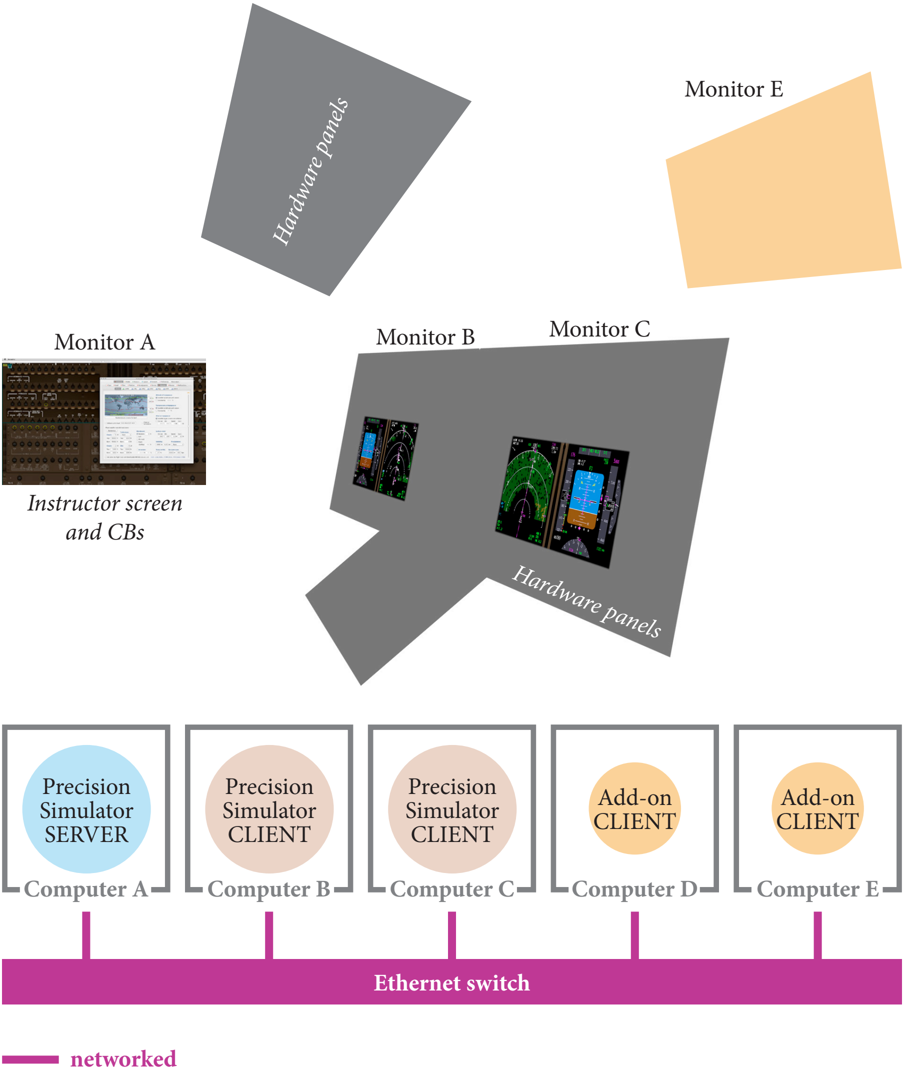
Four Precision Simulators on four computers provide four flight deck frames to four monitors. One add-on is connected and drives an external scenery generator.



Network Examples:

Example 10

Three Precision Simulators on three computers provide three flight deck frames to three monitors. Two add-ons drive hardware and an external scenery generator.



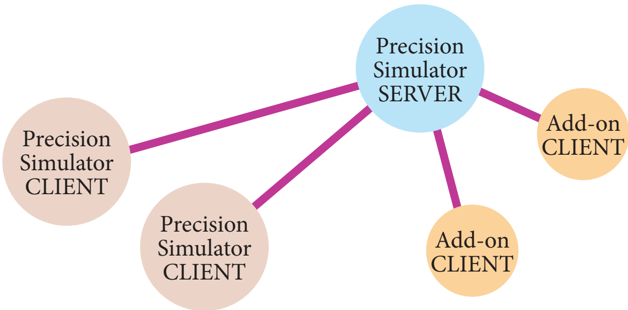
Network Examples:

Summary

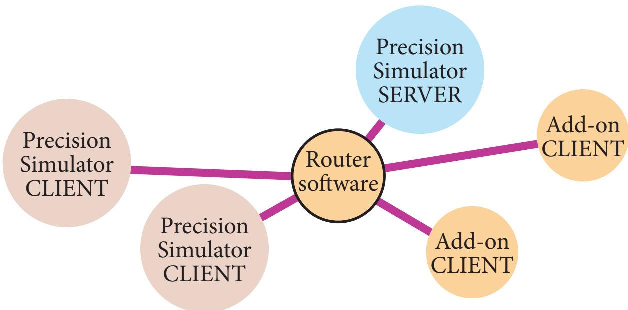
Every example shown on the previous pages can be combined with other examples. And each example can be extended. Moreover, every layout on each monitor can be modified—that is: panned, zoomed, divided, as desired—and stored in layout files. The stored presets can be switched by a click of a button.

Optional Third-Party Router Software:

Normally, one of the networked Precision Simulators is the main server, and every client connects to this server on port 10747. This illustration shows a *normal* setup:



Software and hardware developers may consider using a *router software* as the main server instead of the Precision Simulator main server. The router software (third-party, not an Aerowinx product) can provide data filters, debugging tools, and other features. The next illustration shows a router software acting as a main server. All clients connect to it on port 10748. The router software connects to the actual Precision Simulator main server on port 10747:



Boost Server:

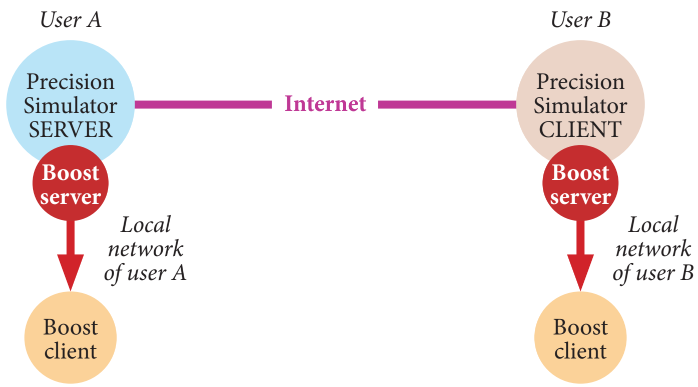
There are three selectable network tasks:

- Main client
- Main server
- Boost server

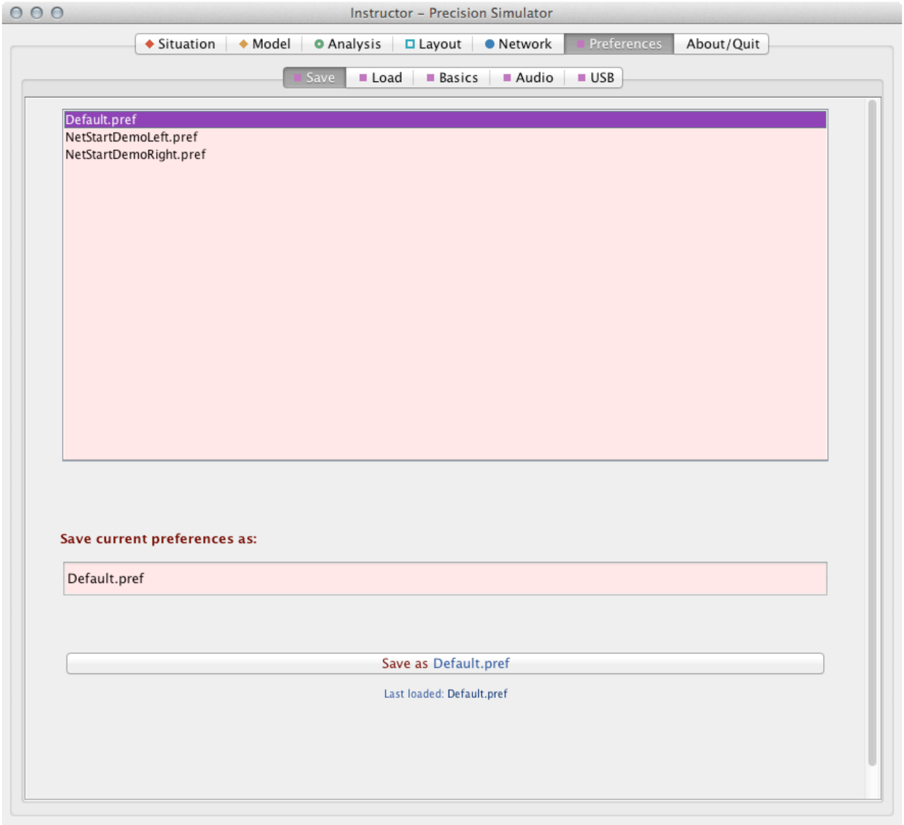
In the main network, one Precision Simulator is the main server, and all other Precision Simulators are main clients. Aerodynamic data are transferred from the main server to the main clients at 5 Hz. Flight control inputs and other controls are transferred instantly and in any network direction, but only when a value has changed. By this technique, data traffic is very low, and the simulated aircraft can be manually flown even via the Internet. To achieve frame rates higher than 5 fps at the other end of the network, the Precision Simulator clients do not extrapolate the incoming data; they just run the same aerodynamics model the server runs. The model is deterministic, based on instant flight control inputs and known atmosphere data. Therefore, the clients need not *estimate* any vectors; they *know* the vectors, and accordingly generate their own aerodynamics sufficiently fast for frame rates up to 72 fps. There are minor fluctuations, but the synchronization at 5 Hz is fast enough to compensate them before they become apparent to the eye.

What the server sends to the *Precision Simulator* clients, is also sent to *add-on* clients. Now, for external scenery generators or motion platform drivers, the data rate of 5 Hz is too low. The boost server solves this problem. Add-ons may, as usual, connect to the main server on port 10747; however, they can also connect to a local boost server on port 10749. The boost server sends aerodynamic data at rates up to 72 Hz.

Do not send boost server data through the Internet. Every main client at the other end of the Internet connection can be used as a boost server—locally—to drive, for example, an external scenery generator (boost client) at high speed:

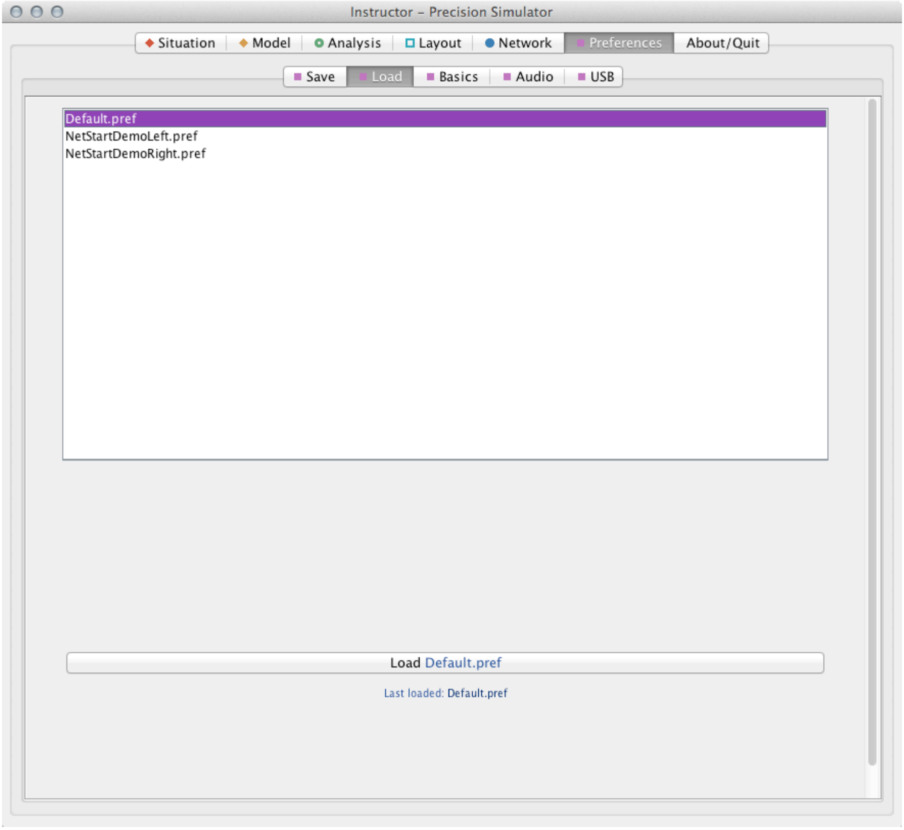


Instructor > Preferences > Save:



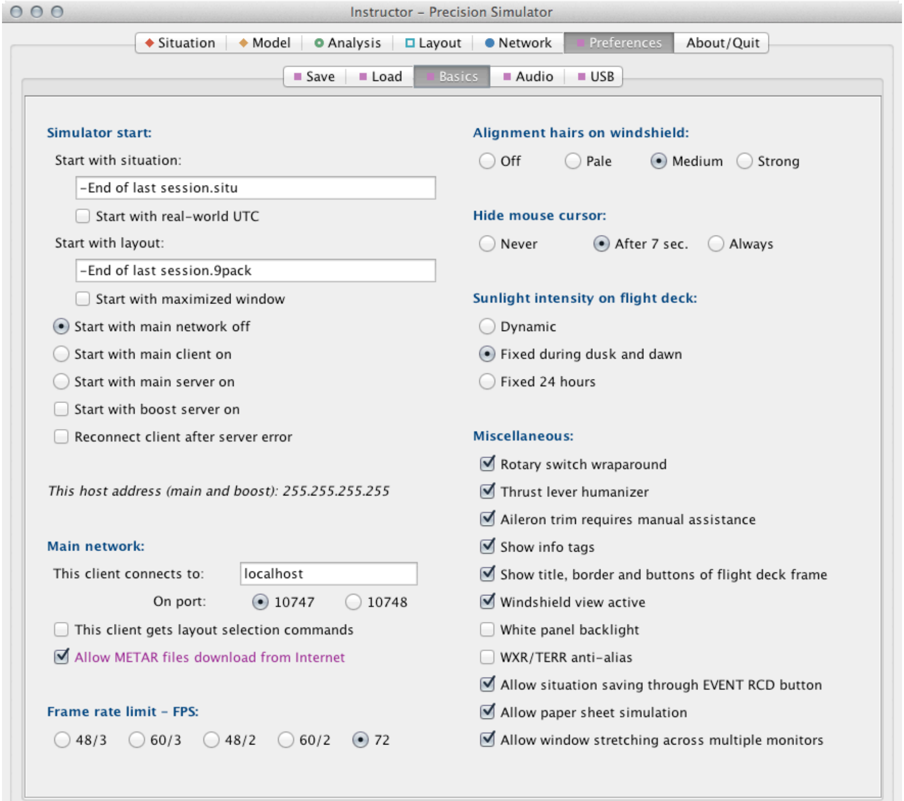
- This page may be used to save the preferences that are currently set on the three pages **Basics**, **Audio**, and **USB**.
- The name of the file to be saved can be edited in the lower edit field. The simulator will add a *.pref* suffix if it is not entered already.
- When the **Save as** button is clicked, the button label changes to **Confirm: Save as**, requiring a second click for confirmation. Only this second click will save the file. When not confirmed within 5 seconds, the button label is reset to **Save as**.
- To delete a file, select the respective file on the list, then press the **Delete** key on the keyboard. *Default.pref* cannot be deleted.

Instructor > Preferences > Load:



- This page may be used to load a preferences file.
- To load a file, double-click the desired file on the list.
- The **Load** (or **Reload**) button may be used as well; it will load the file selected on the list.
- To delete a file, select the respective file on the list, then press the **Delete** key on the keyboard. *Default.pref* cannot be deleted.

Instructor > Preferences > Basics:



- Hover the mouse over an object on this page to show tooltips with descriptions.
- The preferences may be configured so that network components start automatically when the simulator starts. Select the respective **Start with ...** option.
- If the page shown is that of the main server, note the address displayed after "*This host address (main and boost)*". If the indicated address seems invalid, press the Esc key twice to refresh the page.
- If the page shown is that of a main client, enter the server's host address (that you looked up on the other Precision Simulator) into the **Client connects to host** edit field. If the client and the server run on the same computer, enter *localhost* into that field. Select **On port: 10747** when connecting directly to a Precision Simulator main server; or select **On port: 10748** when connecting to a third-party router software.
- At program start, the simulator loads *Default.pref* which is automatically overwritten with the current preferences when quitting the simulator.

(continued next page)

Instructor > Preferences > Basics: *(continued)*

Optional method to start multiple instances on one computer

Double-click the file *AerowinxNetStart.jar* located in the *Aerowinx* folder. This method loads the text file *AerowinxNetStart.**ini*** which is also located in the *Aerowinx* folder. *AerowinxNetStart.**ini*** can be modified with a text editor. Every text line in this file commands one simulator instance to start. A command just consists of the name of the preferences file which that instance should load. The text may look like this:

NetStartDemoLeft.pref
NetStartDemoRight.pref

In this example, two Precision Simulators will start on the same computer; the first one with the preferences *NetStartDemoLeft.pref*, and the second one with *NetStartDemoRight.pref*. There is a pause of 5 seconds between each start.

Option for software developers

The simulator can be forced to load a specific preferences file—other than *Default.pref*—at program start by using the Apple Terminal, or Microsoft Command Prompt, or any similar shell. Change to the *Aerowinx* folder, then enter, for example:

java -jar AerowinxStart.jar Captain.pref

The parameter at the end—*Captain.pref* in this example—is the name of your special preferences file. It must exist in the subfolder *Preferences*. If it does not exist, or if no parameter is entered, *Default.pref* will be loaded. Such commands may be used in a script that starts multiple networked Precision Simulators, each with individual preferences.

Further options

A **.pref* file can be edited with a text editor. It contains additional features that are not displayed on the Instructor. For example:

ShowInstructor=1	*0 = Instructor is hidden at simulator start*
AlternateJavaFont=Microsoft Sans Serif	
AlternateMacFont=	*If not blank, uses non-standard font on Instructor*
JavaLookFeelOnMac=0	*1 = Apple OS X shows standard Java look & feel*

(continued next page)

Instructor > Preferences > Basics: *(continued)*

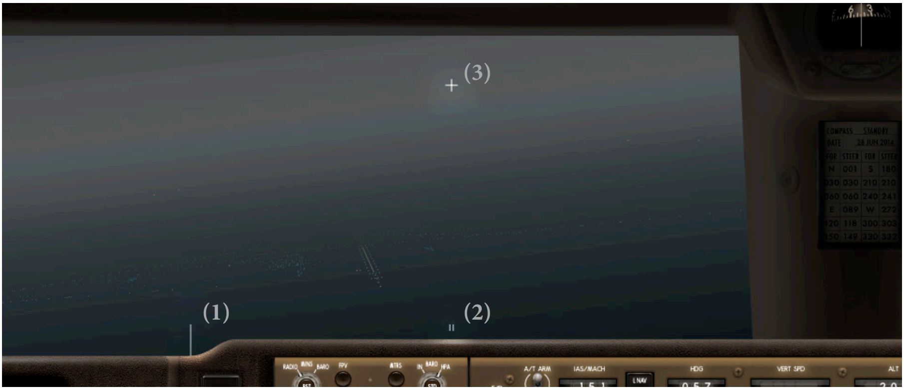
Alignment hairs on the windshield

This is a feature of the simulator; it does not belong to the aircraft systems. The hairs can be enabled on **Instructor > Preferences > Basics** by selecting a brightness level **Pale**, **Medium**, or **Strong**. Indicated on the windshield are the aircraft *track*, *heading*, and *pitch* relative to the scenery horizon. In the sample picture below, the *track* hair (1) is currently left of the *heading* hair (2), indicating a large crab angle to the right. The cross (3) indicates the aircraft *pitch* relative to the scenery horizon; the cross is always vertically in line with the heading hair. The cross and the heading hair are always centered on the x-axis of the respective windshield area shown within a subframe.

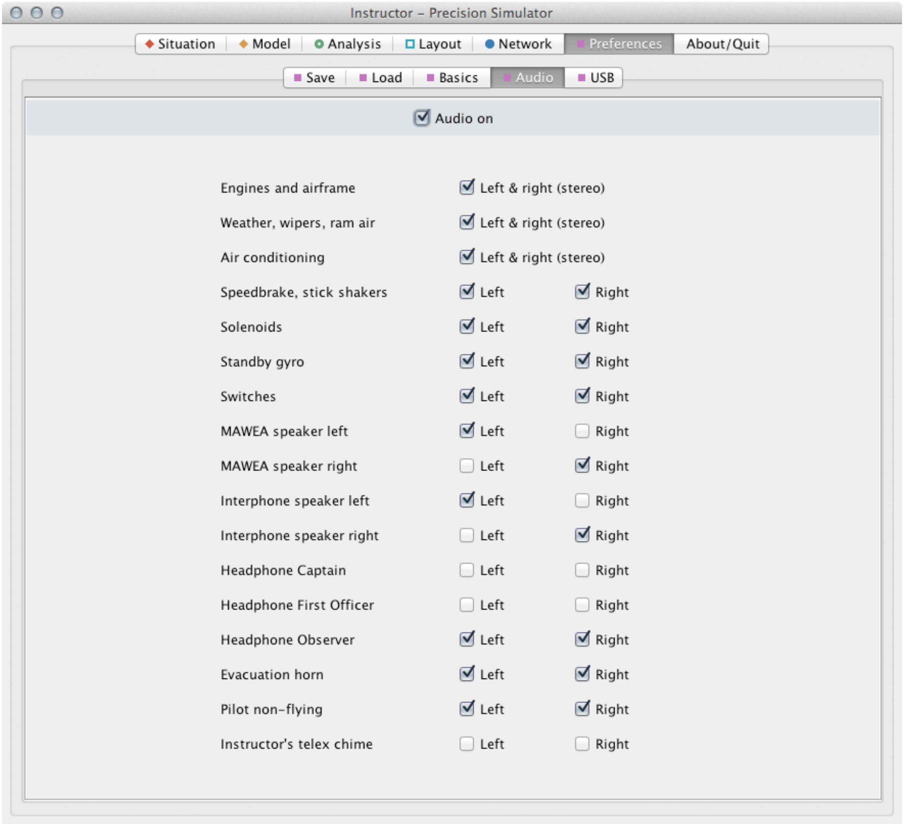
The *track* hair position is dynamic, depending on the present crosswind and current thrust and airframe symmetry. On approach, for example, steer the aircraft so that the *track* hair is aligned with the runway centerline.

The view out of the windshield is slightly downward-tilted. Therefore, when the aircraft pitch is zero, the scenery horizon is located slightly above the windshield's vertical center. Note: When parked on the ground, the aircraft attitude will be level with the mean sea level, even when parked on an uphill or downhill slope. The simulated aircraft will only align with the slope when the groundspeed is not zero. Gear strut compression may modulate the attitude any time, also when parked.

During a tail strike, pod strike, or wing strike, the hairs change to a thicker, blurred indication ("vibrating hairs").



Instructor > Preferences > Audio:

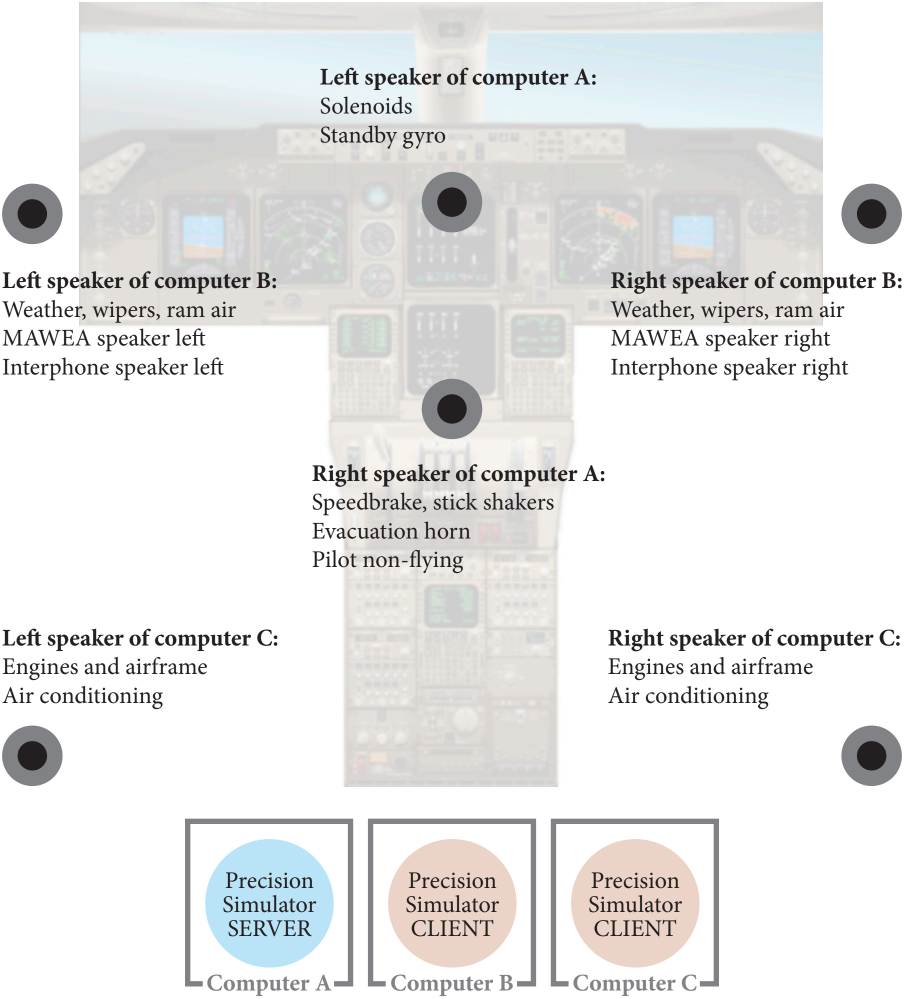


- This page lists sounds and sound groups that can be individually selected.
- When running multiple Precision Simulators on one computer, the **Audio on** checkbox should be deselected on all Precision Simulators but one. This prevents phasing effects.
- Every Precision Simulator in a multicomputer network may play a different set of sounds. Each computer has its own stereo output, driving its own pair of speakers. Thus, each computer's speakers can be placed at specific locations inside a flight deck mockup.
- The first three sound groups—**Engines and airframe** through **Air conditioning**—provide stereo sounds; they generate a spatial "wall of sound" across the stereo panorama. Therefore, the stereo speakers that play these sound groups should be set to equal volumes; this is also the reason why there is only one master checkbox for each of these stereo sound groups.
- The other sound groups generate mono sounds; such a group can be played on a left or on a right speaker, or on two speakers simultaneously.

(continued next page)

Instructor > Preferences > Audio: *(continued)*

- Do not assign a sound group to the left speaker of *one* computer and to the right speaker of *another* computer. This causes undesired echo and phasing effects. The network is fast enough to synchronize visual features, but too slow to synchronize audio waves. A delay of a fraction of a millisecond is already enough to generate audio interference. Therefore, assign the interphone speaker pair, for instance, to the left and right speakers of one computer. The same should be considered for the MAWEA speakers and the stereo groups. **For example:**



(continued next page)

Instructor > Preferences > Audio: *(continued)*

Computer A:

Engines and airframe	☐ Left & right (stereo)	
Weather, wipers, ram air	☐ Left & right (stereo)	
Air conditioning	☐ Left & right (stereo)	
Speedbrake, stick shakers	☐ Left	☑ Right
Solenoids	☑ Left	☐ Right
Standby gyro	☑ Left	☐ Right
Switches	☐ Left	☐ Right
MAWEA speaker left	☐ Left	☐ Right
MAWEA speaker right	☐ Left	☐ Right
Interphone speaker left	☐ Left	☐ Right
Interphone speaker right	☐ Left	☐ Right
Headphone Captain	☐ Left	☐ Right
Headphone First Officer	☐ Left	☐ Right
Headphone Observer	☐ Left	☐ Right
Evacuation horn	☐ Left	☑ Right
Pilot non-flying	☐ Left	☑ Right
Instructor's telex chime	☐ Left	☐ Right

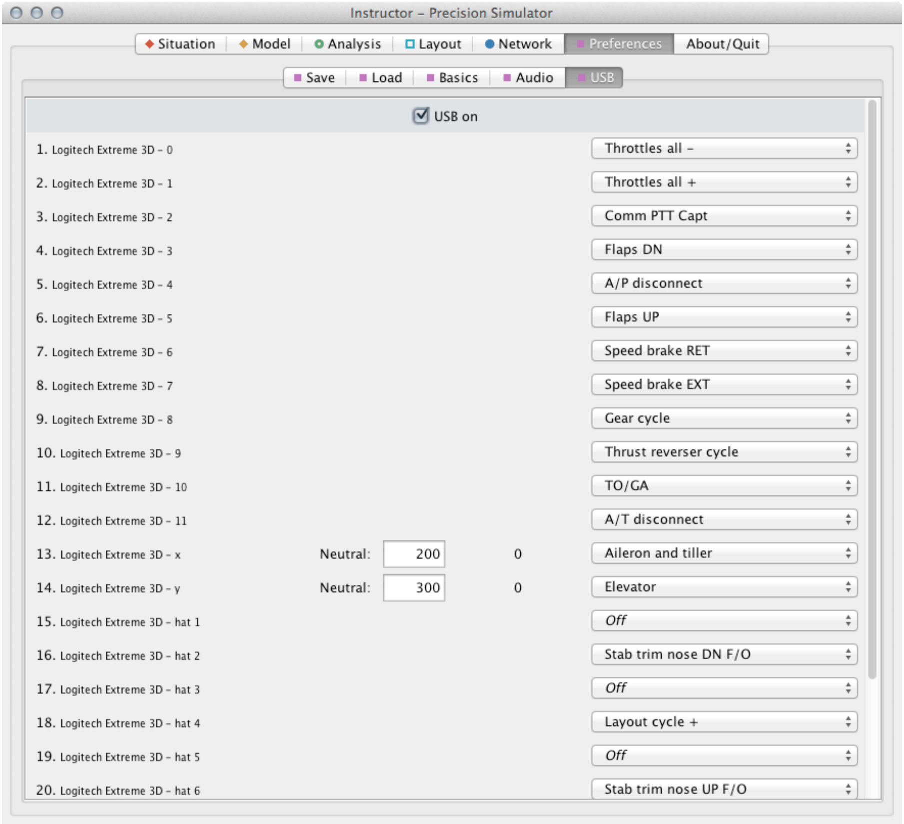
Computer B:

Engines and airframe	☐ Left & right (stereo)	
Weather, wipers, ram air	☑ Left & right (stereo)	
Air conditioning	☐ Left & right (stereo)	
Speedbrake, stick shakers	☐ Left	☐ Right
Solenoids	☐ Left	☐ Right
Standby gyro	☐ Left	☐ Right
Switches	☐ Left	☐ Right
MAWEA speaker left	☑ Left	☐ Right
MAWEA speaker right	☐ Left	☑ Right
Interphone speaker left	☑ Left	☐ Right
Interphone speaker right	☐ Left	☑ Right
Headphone Captain	☐ Left	☐ Right
Headphone First Officer	☐ Left	☐ Right
Headphone Observer	☐ Left	☐ Right
Evacuation horn	☐ Left	☐ Right
Pilot non-flying	☐ Left	☐ Right
Instructor's telex chime	☐ Left	☐ Right

Computer C:

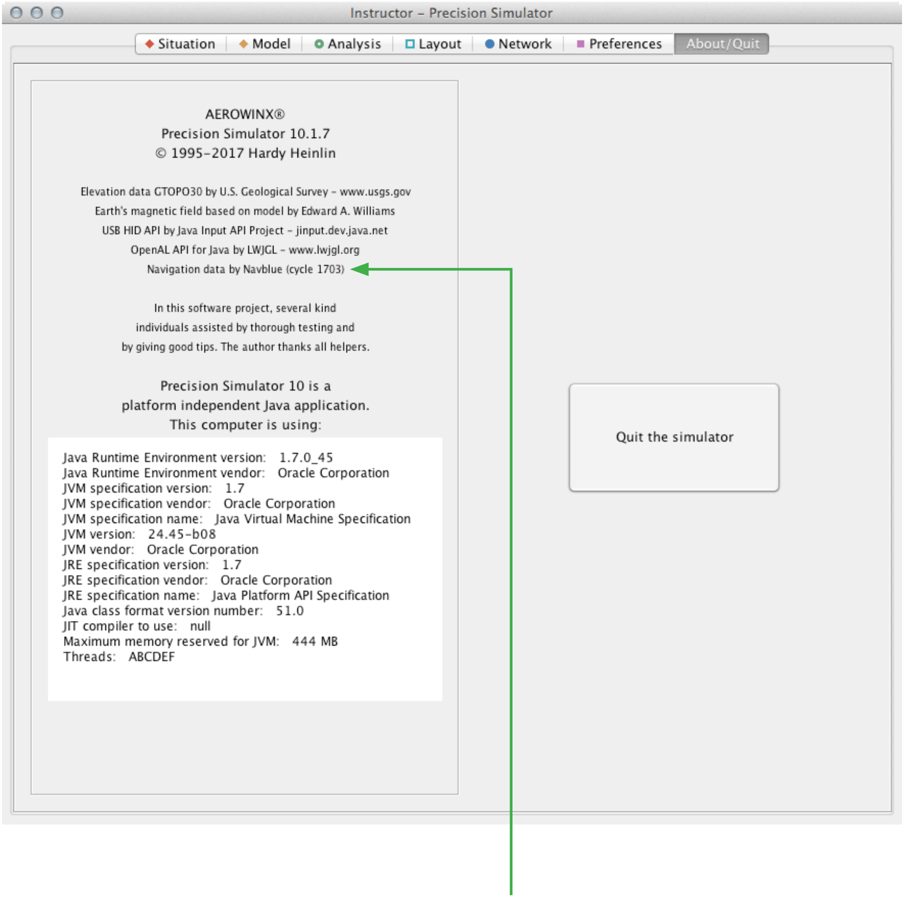
Engines and airframe	☑ Left & right (stereo)	
Weather, wipers, ram air	☐ Left & right (stereo)	
Air conditioning	☑ Left & right (stereo)	
Speedbrake, stick shakers	☐ Left	☐ Right
Solenoids	☐ Left	☐ Right
Standby gyro	☐ Left	☐ Right
Switches	☐ Left	☐ Right
MAWEA speaker left	☐ Left	☐ Right
MAWEA speaker right	☐ Left	☐ Right
Interphone speaker left	☐ Left	☐ Right
Interphone speaker right	☐ Left	☐ Right
Headphone Captain	☐ Left	☐ Right
Headphone First Officer	☐ Left	☐ Right
Headphone Observer	☐ Left	☐ Right
Evacuation horn	☐ Left	☐ Right
Pilot non-flying	☐ Left	☐ Right
Instructor's telex chime	☐ Left	☐ Right

Instructor > Preferences > USB:



- Through the combo boxes on the right-hand side, assign simulator functions to USB inputs.
- When running multiple Precision Simulators on *one* computer, the **USB on** checkbox should be deselected on all Precision Simulators but one. Otherwise, every USB input will be multiplied through the network inside this computer and cause input errors.
- When running multiple Precision Simulators on *different* computers, each Precision Simulator may be assigned to any USB functions. However, be sure to assign pilot seat specific functions like the PTT and stabilizer trim switches to the respective onside controls of the captain and first officer.
- For each axis and slider, enter a value in the associated **Neutral** edit field that keeps the input stable when the control is not moved. To reverse an axis, set a negative value, for example -1.
- The function **Aileron and tiller** acts as a gear steering tiller when the groundspeed is above 0 and below 40 kt, otherwise it acts as an aileron control wheel.

Instructor > About/Quit:



- The navigation database AIRAC cycle currently used in this simulator is indicated after *"Navigation data by ..."* That same database is also used in the simulated FMS (regardless of the dates displayed on the FMC IDENT page; those dates on the FMC IDENT page are simulated dates for FMS training purposes and vary with the simulation time set on **Instructor > Situation > Time**).

Hiding and Showing the Instructor:

The Esc key on the keyboard should be used to hide and show the Instructor. Should the Esc key not work in a specific case, it is most likely because none of the objects on the Instructor (buttons, edit fields, and so on) have the focus at the moment (none of them are highlighted). In that case, all key listeners are deactivated. To solve this problem, press the Tab key to put the focus on an object, or click with the mouse on an object.

Documentation for Add-on Developers:

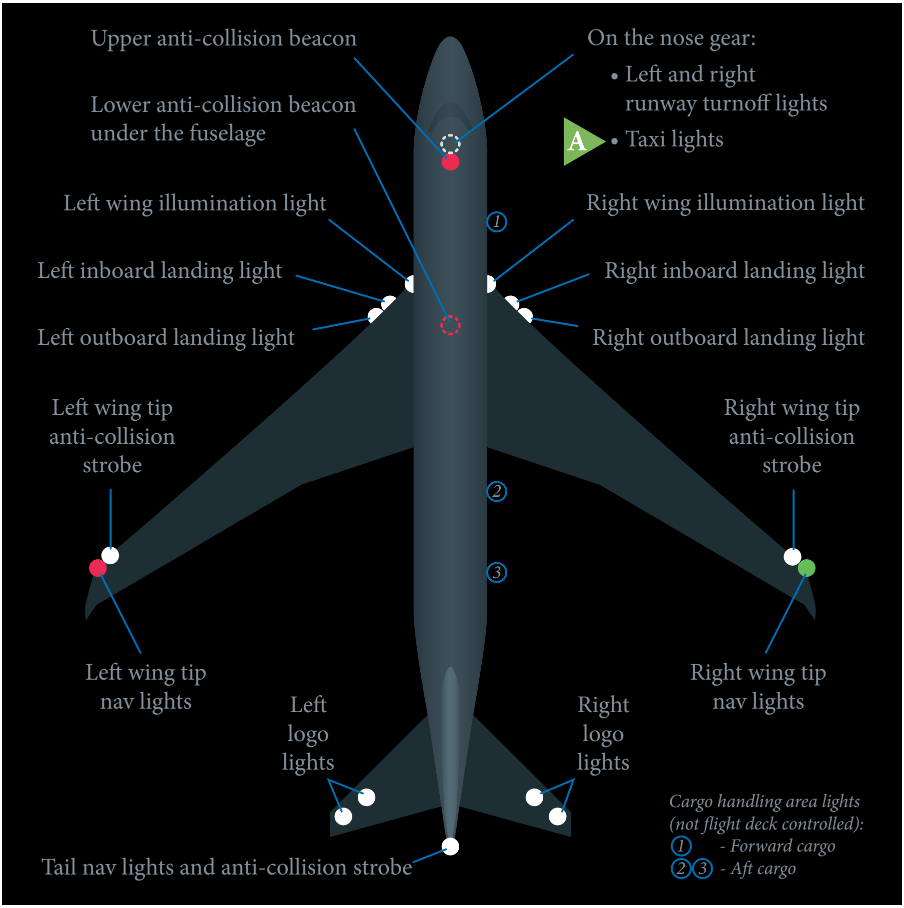
Refer to the files and code samples in the subfolder *Developers*. If you have specific questions or inquiries, please post a message in the *Networkers* section of the 744 forum at *aerowinx.com*.

Aircraft General

Basic Dimensions:

Aircraft length, including rudder tip	70.7 m	231 ft 10 in
Wing span, fuel tanks full	64.9 m	212 ft 10 in
Wing height at winglet tip, fuel tanks full	6.7 m	22 ft 00 in
Tail height	19.4 m	63 ft 08 in
Upper deck roof height	9.9 m	32 ft 06 in

Exterior Lighting Locations:



Exterior Lighting Controls:

A Toggle switch directions are aircraft specific; the ON function may be in the upper or in the lower position.

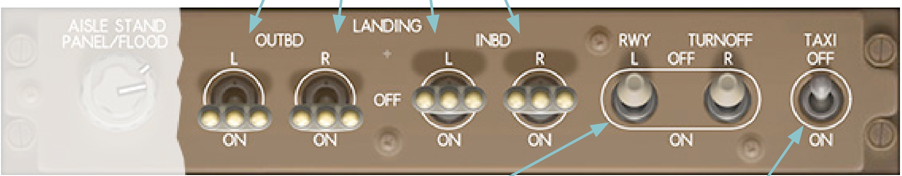
PNF In the simulator, the logo and landing lights may be set by the virtual Pilot Non-Flying (PNF) when passing 10000 feet to relieve the flying pilot in a one-crew simulator session. The PNF can be deactivated on **Instructor** > **Situation** > **Human** > **Pilot** by clearing the checkbox **Performs silent tasks**.

Landing light switch
(outboard left, outboard right, inboard left, inboard right)

ON Activates the respective landing light.

Maximum brightness is automatically enabled when the gear lever is in DN position or when only the outboard landing lights are on.

Low voltage heating power is automatically applied when the gear lever is not in DN position and the landing light switch is off.



Runway turnoff light switch (left, right)

ON Enables activation of respective left or right runway turnoff light on nose gear.

Light power is automatically disconnected when airborne.

A **Taxi lights switch**

ON Enables activation of left and right taxi lights on nose gear.

Light power is automatically disconnected when airborne.

SYSTEM ANALYSIS In the simulator, the present voltage at each exterior light is indicated on **Instructor** > **Analysis** > **Miscellaneous** under **Exterior lights power**: Each digit ranges from 0 to 9 where 9 corresponds to maximum voltage. This string of digits is also accessible through the simulator's main network.

Exterior Lighting Controls:

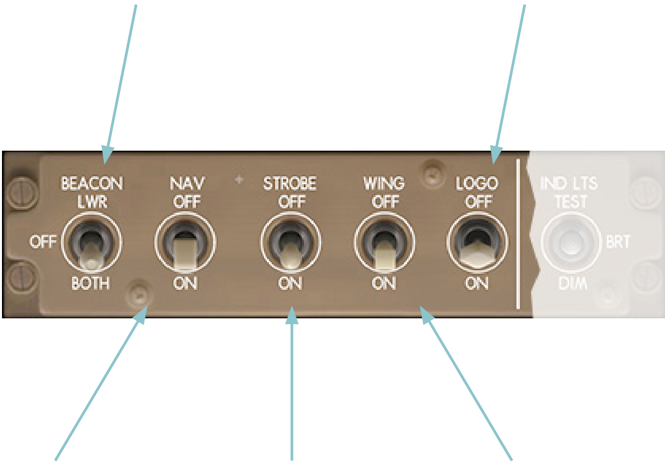
Beacon light switch

LWR Activates lower red anti-collision beacon light.

BOTH Activates upper and lower red anti-collision beacon light.

Logo light switch

ON Activates all four logo lights (or six on some aircraft) on horizontal stabilizer for illumination of airline logo on vertical stabilizer.



Nav light switch

ON Activates red and green nav lights on wing tips and white nav lights on tail.

Strobe light switch

ON Activates white strobe lights on tail and both wing tips.

Wing light switch

ON Activates left and right wing illumination lights, allowing crew to visually check wing leading edges and engine nacelles for ice accumulation.

Main Panel Lighting:

Left panel light control

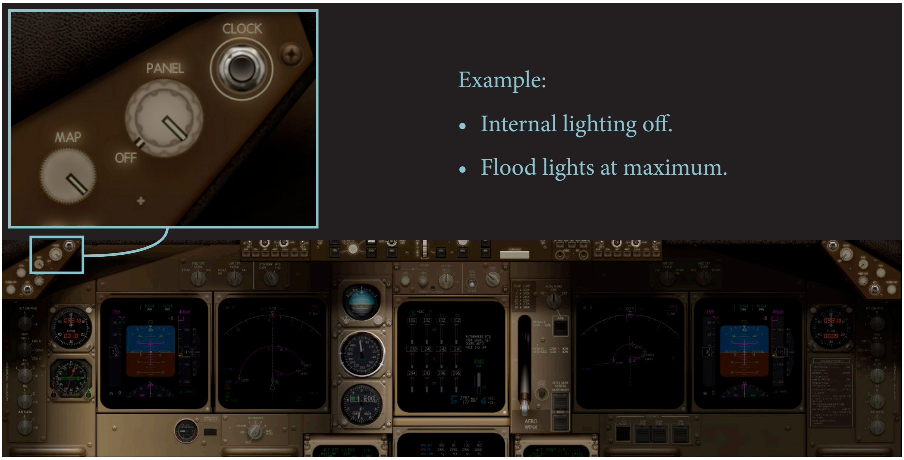
Outer knob

Controls internal lighting of left and center main panels.

A Also controls standby compass lighting.

Inner knob

Controls external flood light onto left and center main panels.



Main Panel Lighting:

Right panel light control

Outer knob

Controls internal lighting of right main panel.

Inner knob

Controls external flood light onto right main panel.

Glareshield Panel Lighting:

Glareshield panel light control

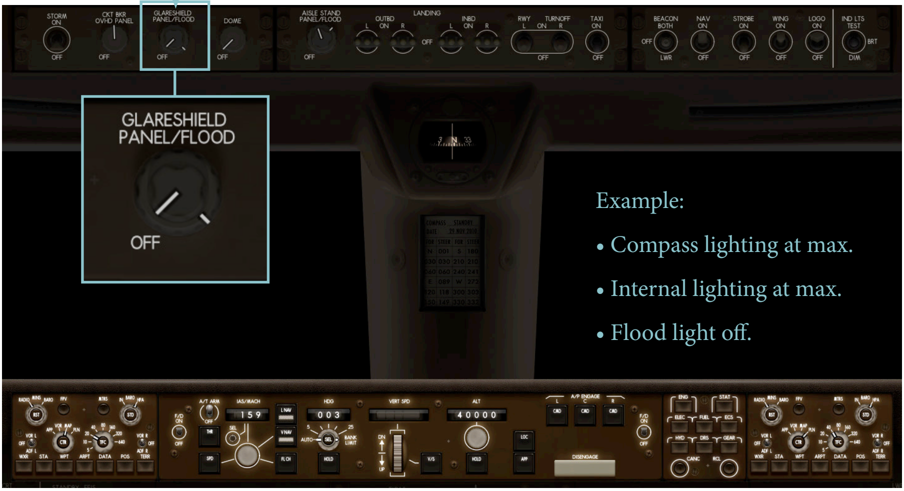
Outer knob

Controls internal lighting of glareshield panel.

A Also controls standby compass lighting.

Inner knob

Controls glareshield flood light.



Aisle Stand Lighting:

Aisle stand light control

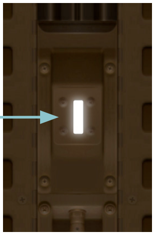
Outer knob

Controls internal lighting of aisle stand panels.

Inner knob

Controls aisle stand flood light.

Aisle stand flood light



Example: Internal lighting max., flood off.

Example: Internal lighting off, flood max.

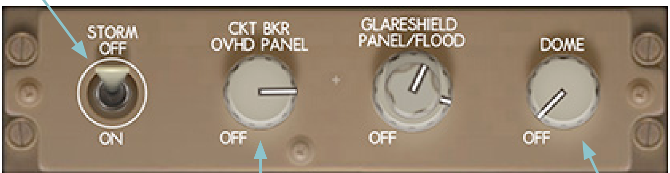
Storm and Overhead Lights:

Storm light switch

ON Sets flood and internal lights of glareshield, aisle, and main panel, as well as dome lights to maximum brightness. Overrides normal controls.

Dome lights

Map lights



Overhead panel light control

Rotate

Controls internal lighting of overhead panel, including circuit breaker panel.

Dome light control

Rotate

Controls dome lights.

Left map light control

Pull to activate, rotate to dim.

Right map light control

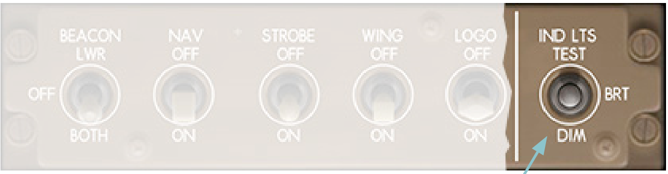
Pull to activate, rotate to dim.

Maintenance Panel:

Flight deck access lights switch

Push Activates various lights along path from outside to flight deck for guidance on dark aircraft. Only available when ground handling bus is powered.

Indicator Lights Control:



Indicator lights switch

TEST (momentary action) As long as held in TEST position, illuminates all indicator lights on flight deck except for:
- Squib lights
- APU and engine related fire warning lights
- Printer status lights
- EVAC light

Applies maximum brightness initially for 10 seconds, then dimmed brightness until switch is released.

BRT Activates maximum brightness for day operation.

DIM Activates dimmed brightness for night operation. Not dimmable are:
- ON BAT lights of towing power and IRS power
- ELT light
- Cargo fire warning lights on passenger aircraft
- Red WARNING light in master warning switches

Indicator Lights:

Indicator lights are integrated in pushbuttons or in separate casings. These lights cannot be dimmed by the panel light control knobs; indicator lights are powered separately by the Master Dim & Test system (MD & T). Still, dimming is possible. Two fixed brightness levels are available: one for daytime, one for nighttime conditions. The levels can be selected by setting the IND LTS switch on the overhead panel to the BRT or to the DIM position.

This switch also has a TEST position which powers all indicator lights on the flight deck for bulb checking. For safety reasons, each indicator light typically contains more than one bulb. When a light is activated, all of its in-built bulbs are powered; which means, if one of them is blown, the light appears dimmed even if the IND LTS switch is not in the DIM position.

Pushbuttons:

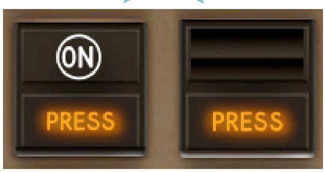
Two types of pushbuttons are in use: momentary action switches and alternate action switches.

Momentary action switches stay in the ON position only as long as they are pushed; when released, internal springs force them to the OFF position.

Alternate action switches alternate between ON and OFF upon each push, and maintain their positions when released. Alternate action switches contain a black mechanical shutter: when pushing the switch in, the shutter uncovers a white backlit word or bar. Under daylight conditions, the word or bar is visible even without backlight. The backlight is continuously dimmable by the panel light control of the respective flight deck section.

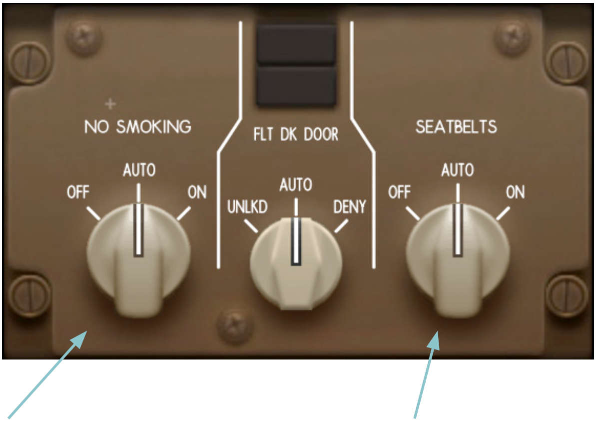
Typical **momentary action** switch with indicator light in lower half.

Typical **alternate action** switch with shutter in upper half and indicator light in lower half.



Pushed Released

Passenger Signs:



No smoking signs selector

OFF NO SMOKING signs illuminate when passenger oxygen deployed.

AUTO NO SMOKING signs illuminate when gear down, or cabin altitude above 10000 feet, or passenger oxygen deployed.

ON NO SMOKING signs illuminate.

Seatbelts signs selector

OFF RETURN TO SEATS signs extinguish. FASTEN SEATBELTS signs illuminate when passenger oxygen deployed.

AUTO FASTEN SEATBELTS and RETURN TO SEATS signs illuminate when gear down, or flap lever out of up, or cabin altitude above 10000 feet,

A or aircraft below 10000 feet.

FASTEN SEATBELTS signs illuminate and RETURN TO SEATS signs extinguish when passenger oxygen deployed.

ON FASTEN SEATBELTS and RETURN TO SEATS signs illuminate.

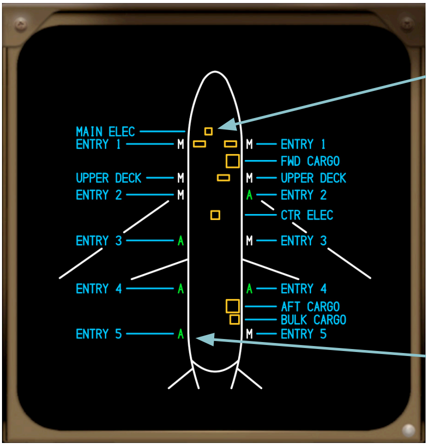
SYSTEM ANALYSIS In the simulator, the currently illuminated passenger signs are indicated on **Instructor > Analysis > Miscellaneous** under **Passenger signs**. The status of the signs is also accessible through the simulator's main network.

EICAS Doors Synoptics:

Doors synoptic switch

First push Shows doors synoptic on secondary EICAS display.

Second push Blanks secondary EICAS display.



Passenger model

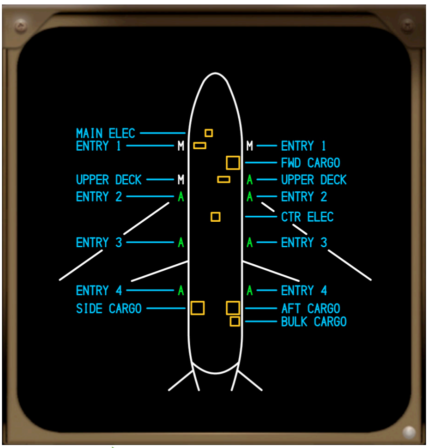
Door status indication

Amber rectangle shown when door open.

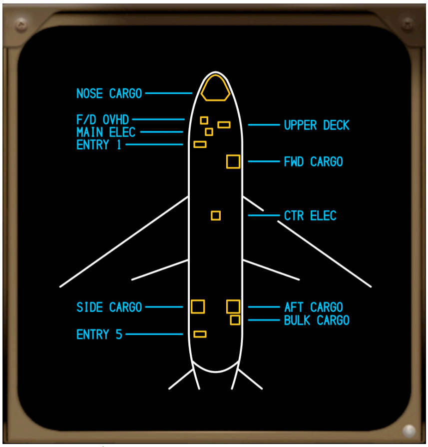
Door escape slide mode indication

M Door mode selector in manual position (park mode).

A Door mode selector in automatic position (flight mode).



Combi model



Freighter model

Door Opening and Closing:

The nose cargo door on the freighter can only be operated when the cargo handling bus is powered; it is powered when APU generator 2 is running and disconnected from the AC bus tie, or when external power 2 is available and disconnected from the AC bus tie. In other words, when the APU-GEN-2 or EXT-PWR-2 AVAIL light on the overhead panel is on, the nose cargo door can be moved. If just an ON light is illuminated on the APU-GEN-2 and EXT-PWR-2 switches, the cargo handling bus is not powered.

When opening, the doors swing to the outside; however, most door systems are constructed so that they first open inward. That is, cabin air pressure pushes the doors to their closed positions. This also means that the flight attendants are physically not able to open the doors when the cabin pressure is significantly higher than the ambient pressure.

In the simulator, the doors will remain closed when the cabin differential pressure is not below 0.4 psi.

The simulator uses a random pattern for the opening and closing sequences. There are also a few special conditions: some doors open in the simulation only when the evacuation alert is on; and, when precipitation is simulated, the freighter's forward overhead door remains closed.—The opening and closing sequences can further be restricted by the functions on **Instructor** > **Situation** > **Service** under **Doors**.

The function **Open** will start the opening sequence when the cabin differential pressure is below 0.4 psi.

The function **Open when parked** will start the opening sequence when all of the following conditions are true:

+ Beacon lights are off
+ Seatbelt signs are off
+ All four fuel cutoff switches are set to CUTOFF
+ Cabin differential pressure is below 0.4 psi

When not all conditions are true while any door is open, the closing sequence immediately starts.

The opening and closing sequences can be accelerated with the time acceleration slider on **Instructor** > **Situation** > **Time**.

To force the simulator to open a door in flight when cabin differential pressure is higher than 0.4 psi, use the malfunction features on **Instructor** > **Situation** > **Malfunctions** > **Bleed** under **Cabin depress - gradual**.

EICAS Messages:

CAUTION MESSAGES (accompanied by caution light and beeper sound)		
DOOR AFT CARGO		aft cargo door not closed and locked
DOOR FWD CARGO		forward cargo door not closed and locked
A DOOR SIDE CARGO		side cargo door not closed and locked
A DOOR NOSE CARGO		nose cargo door not closed and locked
DOOR U/D FLT LK		upper deck door flight lock disagrees with command

ADVISORY MESSAGES		
DOOR BULK CARGO		bulk cargo door not closed and latched
DOOR ELEC CTR		center electrical access door not closed and latched *[inhibited by DOORS ELEC]*
DOOR ELEC MAIN		main electrical access door not closed and latched *[inhibited by DOORS ELEC]*
DOOR ENTRY L ()		One left door (1, 2, 3, 4, or 5) not closed and latched *[inhibited by DOORS ENTRY L]*
DOOR ENTRY R ()		One right door (1, 2, 3, 4, or 5) not closed and latched *[inhibited by DOORS ENTRY R]*
A DOOR F/D OVHD		flight deck overhead door not closed and latched
DOOR L UPPER DK		left upper deck door not closed and latched *[inhibited by DOORS UPR DECK]*
DOOR R UPPER DK		right upper deck door not closed and latched *[inhibited by DOORS UPR DECK]*
DOORS ELEC		center and main electrical access doors not closed and latched
DOORS ENTRY L		multiple left entry doors not closed and latched
DOORS ENTRY R		multiple right entry doors not closed and latched
DOORS UPR DECK		left and right upper deck doors not closed and latched

EICAS Messages:

	MEMO MESSAGES		
	DOORS AUTO		all entry and upper deck door escape slides in automatic mode *[inhibited when takeoff thrust applied until 1 minute after landing]*
	DOORS AUTO/MAN		entry and upper deck door escape slides in mixed modes
	DOORS MANUAL		all entry and upper deck door escape slides in manual mode *[inhibited when airborne]*
	NO SMOKING ON		no smoking signs selector in on position *[inhibited by PASS SIGNS ON]*
	PASS SIGNS ON		no smoking signs selector and seatbelts signs selector in on position
	SEATBELTS ON		seatbelts signs selector in on position *[inhibited by PASS SIGNS ON]*
A	STROBE LIGHT OFF		strobe light switch set to off while airborne

	STATUS MESSAGES		
	DOOR AFT CARGO		aft cargo door not closed and locked
	DOOR FWD CARGO		forward cargo door not closed and locked
A	DOOR SIDE CARGO		side cargo door not closed and locked
A	DOOR NOSE CARGO		nose cargo door not closed and locked
	DOOR U/D FLT LK		upper deck door flight lock disagrees with command
A	PASS SERVICES		cabin services system failure

Air Systems

Pack and Pneumatic Controls:

Isolation valve switch (left, right)

ON (bar in view) Valve is commanded to open.

OFF Valve is commanded to close.

VALVE LIGHT Valve position disagrees with switch position.

Pack control selector (1, 2, 3)

OFF Closes pack valve. If all packs with faults are selected off, SYS FAULT light extinguishes. Resets pack fault protection logic for operating packs.

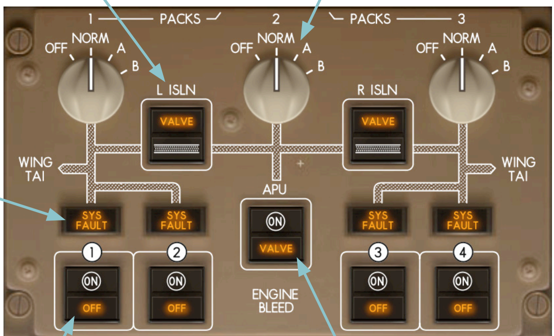
NORM Pack controller A or B is automatically selected on alternate flights. Selected controller is primary controller; other controller operates if primary controller fails.

A Controller A is primary controller; controller B operates if A fails.

B Controller B is primary controller; controller A operates if B fails.

Engine bleed air system fault light (1, 2, 3, 4)

Bleed air overheat or overpressure, or disagreement in valve systems.



Engine bleed air switch (1, 2, 3, 4)

ON When bleed air pressure is available from this engine, system opens PRSOV, PRV*, and HP bleed shutoff valve. System opens PRSOV also when this engine requires bleed air from other sources for engine start.

OFF PRSOV, PRV*, and HP bleed shutoff valve are closed unless thrust reverse *(not on PW engines)* or nacelle anti-ice is activated, and system operates normally.

OFF LIGHT PRSOV is closed.

APU bleed air switch

ON When EICAS memo message APU RUNNING appears, system logic commands APU bleed isolation valve to open.

OFF Valve is commanded to close.

VALVE LIGHT Valve position disagrees with commanded position.

** For RR engines: FWSOV instead of PRV*

Air Conditioning Controls:

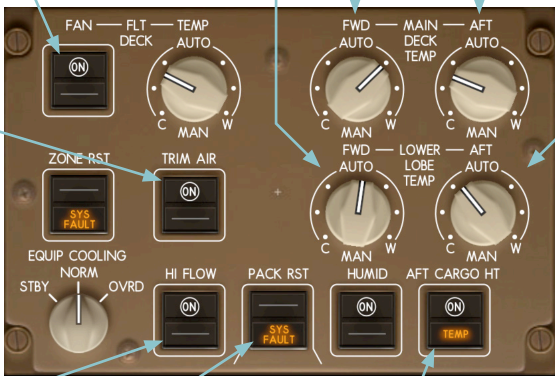
A **Flight deck fan switch**
(on freighter)

ON Flight deck supplied by recirculated cabin air when on ground.

A **Cargo zone temperature selector (main deck forward, aft; lower lobe forward, aft)**
(on freighter)

AUTO Range is 4°C to 27°C (39°F to 81°F) from C to W. Temperature is accordingly adjusted by a zone temperature controller.

MAN Respective trim air valve under manual control. Rotation from MAN to W, and holding selector in W, moves trim air valve toward open position to supply warmer air. Vice versa: MAN to C for cooler air.



Trim air switch

ON Opens master trim air valve and allows zone trim air valves to operate automatically. Allows automatic and manual selection of pack controller A or B.

OFF Closes master trim air valve and sets pack output temperature control in backup mode. Selects pack controller A and inhibits controller B selection.

Pack high flow switch

ON Packs provide high air flow.

OFF Air flow controlled by system logic.

Pack reset switch

Push Restarts pack if automatic shutdown has occurred and if fault is cleared. Resets system fault protection logic.

SYS FAULT LIGHT Pack system fault or overheat.

Lower aft cargo heat switch

ON If temperature not excessive: Opens overheat shutoff valve to supply hot bleed air to lower aft and bulk cargo compartments, and enables automatic operation of temperature control valve.

OFF Closes overheat shutoff valve and temperature control valve.

TEMP LIGHT Excessive compartment temperature. Overheat shutoff valve and temperature control valve closed.

Air Conditioning Controls:

A Passenger zones temperature selector *(not on freighter)*

AUTO Sets master temperature for all passenger zones. Range is 18°C to 29°C (65°F to 85°F) from C to W. Temperatures are accordingly adjusted by a zone temperature controller. In cruise, and if system is not in backup mode, flight attendants can enter corrections by ±6°C on cabin temperature panel at purser station. Range limits cannot be exceeded. *(In simulator, flight attendant inputs are generated randomly.)*

ALTN Bypasses zone temperature controller and deactivates cabin temperature panel at purser station. Zone trim air valves remain in their last positions. Pack output temperature regulation aims at average cabin temperature of 24°C (75°F).

Flight deck temperature selector

AUTO Range is 18°C to 29°C (65°F to 85°F) from C to W. Temperature is accordingly adjusted by a zone temperature controller.

MAN Flight deck trim air valve under manual control. Rotation from MAN to W, and holding selector in W, moves trim air valve toward open position to supply warmer air. Vice versa: MAN to C for cooler air.

A Lower aft cargo temperature selector *(not on freighter)*

AUTO Range is 4°C to 27°C (39°F to 81°F) from C to W. Temperature is accordingly adjusted by a zone temperature controller.

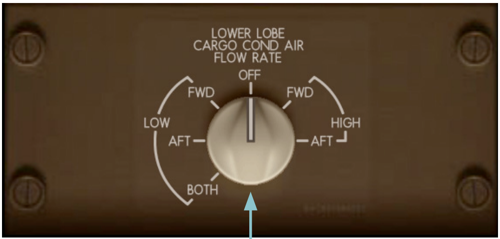
MAN Aft cargo trim air valve under manual control. Rotation from MAN to W, and holding selector in W, moves trim air valve toward open position to supply warmer air. Vice versa: MAN to C for cooler air.

Zone reset switch

Push Resets zone temperature control logic unless fault still exists. Reopens master trim air valve if duct overheat is no longer present.

SYS FAULT LIGHT Zone duct overheat or zone controller fault except for aft cargo zone, or master trim air valve failure, or trim air switch off.

Air Conditioning Controls:



Maintenance panel

A **Lower lobe cargo conditioned air flow rate selector**
(not on passenger aircraft)

LOW BOTH	⅔ of pack 2 & 3 air routed to lower aft & forward cargo compartments.
LOW AFT	⅔ of pack 2 air routed to lower aft cargo compartment.
LOW FWD	⅔ of pack 3 air routed to lower forward cargo compartment.
OFF	No temperature regulation by pack system in lower cargo compartments.
HIGH FWD	All pack 3 air routed to lower forward cargo compartment.
HIGH AFT	All pack 2 air routed to lower aft cargo compartment.

Overhead panel

A **Cargo conditioned air flow rate selector**
(on passenger aircraft)

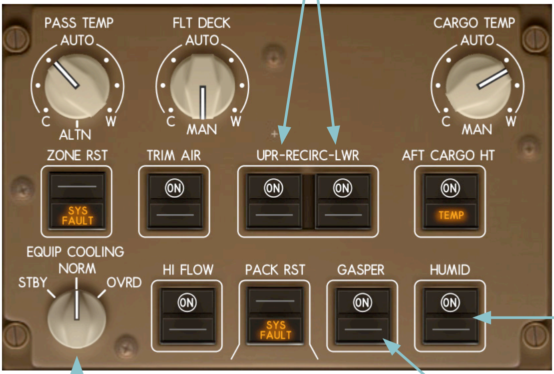
OFF	Conditioned air from pack 3 routed to cabin distribution system. No temperature regulation by pack system in aft cargo compartment.
LO	Conditioned air from pack 3 routed to cabin distribution system and aft cargo compartment.
HI	Conditioned air from pack 3 routed to aft cargo compartment.

Air Conditioning Controls:

A Recirculation fan switch (upper, lower)
(not on freighter)

ON Recirculation fans controlled by system logic.

OFF Recirculation fans deactivated.



Humid switch
(normally not on all aircraft; in simulator installed on all aircraft)

ON Enables flight deck humidifier.

Gasper switch
(normally not on all aircraft; in simulator installed on all aircraft except freighter)

ON Enables system logic to activate gasper fan. When active, passengers can use overhead nozzles to gain additional cooling air.

Equipment cooling selector

STBY Same function as in NORM except that the inboard exhaust valve is open and the ground exhaust valve is closed; automatic control of both valves is bypassed.

NORM In flight, or if at least one engine on each wing is running, equipment cooling air is exhausted into forward cargo compartment. Else: Depending on OAT, equipment cooling air is exhausted into forward cargo compartment or overboard.

OVRD Inboard exhaust valve, ground exhaust valve, and equipment cooling supply valve are closed. Cooling air is supplied through the flight deck panels. The smoke/override valve is open, allowing cooling air to be exhausted overboard by cabin differential pressure.

Cabin Altitude Control:

Outflow valve position indicator (left, right)
Indicates outflow valve position.

OP Toward open.

CL Toward closed.

Landing altitude switch

Push Alternates landing altitude control between manual mode and automatic mode.

Automatic mode:
AUTO is indicated on primary EICAS. Landing altitude is set by FMS.

Manual mode:
MAN is indicated on primary EICAS. Landing altitude is set by landing altitude selector.

Cabin altitude controller selector

NORM Cabin altitude controller A or B is automatically selected on alternate flights. Selected controller is primary controller; other controller operates if primary controller fails.

A Controller A is primary controller; controller B operates if A fails.

B Controller B is primary controller; controller A operates if B fails.

Landing altitude selector

Rotate Sets landing altitude when in manual mode. Setting is displayed on primary EICAS.

Outflow valve manual control switch
Changes positions of outflow valves that are in manual control mode.

OPEN Outflow valve moves toward open. Cabin altitude increases.

CLOSE Outflow valve moves toward closed. Cabin altitude decreases.

Outflow valve manual switch (MAN L, MAN R)

ON Bypasses automatic outflow valve control and cabin altitude limiter to enable manual control.

OFF Outflow valve controlled by system logic.

EICAS ECS Display Control:

ECS (environmental control system) synoptic switch

First push Shows ECS synoptic on secondary EICAS display. Shows duct pressure and cabin altitude indications on primary EICAS display.

Second push Blanks secondary EICAS display. Removes duct pressure and cabin altitude indications if parameters are in normal range.

Duct Pressure and Cabin Altitude Indications:

Displayed if at least one of the following conditions is true:

- ECS or ENG synoptic is selected
- Any indication is amber or red
- CABIN ALT AUTO caution message is displayed
- BLD DUCT LEAK caution message is displayed
- Cabin altitude is above 7400 ft
- Cabin altitude rate is above 700 fpm or below -500 fpm

Left and right bleed air duct pressure in psi. Amber if below 12.

Cabin altitude in ft. Amber if above 8500. Red if above 10000.

Cabin altitude rate in fpm.

Landing altitude setting. Blank if both cabin altitude controllers A and B fail, or if both outflow valves manually controlled.

Landing altitude control mode: MAN in amber, or AUTO in white.

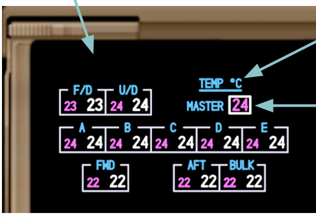
Cabin differential pressure in psi. White if within -0.4 and 8.8, else: Amber if within -0.9 and 9.0, else: Red, and remains red until returned to white range.

EICAS ECS Synoptic:

A **Zone temperatures**

Target temperatures displayed in magenta, and actual temperatures in white, for each zone: flight deck (F/D), upper deck (U/D), passenger zones A to E; and lower deck forward, aft, bulk cargo (FWD, AFT, BULK).

A ECS temperature indications are in °C or °F as specified by airline



Master target temperature for passenger zones

Outflow valve positions and control modes

Pack high flow indication

Pack controller in use

Freighter specific zones: crew rest (C/R), and main deck cargo zones (FWD, AFT).

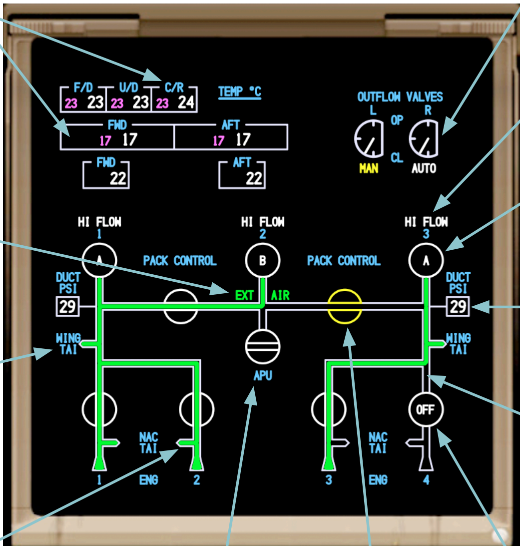
External bleed air indication

Wing anti-ice indication

Nacelle anti-ice indication

Bleed air duct pressure in psi. Amber if below 12.

Air flow in green, blank if no flow; based on valve, switch and pack states.



APU bleed air isolation valve; amber if disagreement.

Isolation valve; amber if disagreement.

Engine bleed air valve

Equipment Cooling:

Cool cabin air from the lower deck is used to cool the avionics on the flight deck and in the electronic equipment compartments. Automatically controlled fans and valves lead the air through a manifold. The warm air coming out of the equipment racks is directed overboard or into the forward cargo compartment. Depending on the equipment cooling selector position, the system logic controls the fans and valves as follows:

	Supply fan	*Exhaust fan*	*Smoke/override valve*	*Inboard supply valve*	*Inboard exhaust valve*	*Ground exhaust valve*	*Bypass valve*	*E6/E9 valve*
On ground, engines out, skin temperature < 7°C, NORM or STBY selected	on	on	close	open	open	close	close	open
On ground, engines out, skin temperature > 7°C, NORM selected	on	on	close	open	close	open	close	open
On ground, engines out, skin temperature > 7°C, STBY selected	on	on	close	open	open	close	close	open
On ground, engines on, NORM or STBY selected	on	on	close	open	open	close	close	open
In flight, NORM or STBY selected	on	on	close	open	open	close	close	open
Clean mode or OVRD selected	off	off	open	close	close	close	close	open
Single fan failure			close	close	close	close	open	open
Cargo fire armed	off	off	open	close	close	close	close	close

SYSTEM ANALYSIS In the simulator, the status of the equipment cooling fans and valves can be checked on **Instructor > Analysis > Miscellaneous**. The data is also accessible through the simulator's main network.

Bleed Air System:

Bleed air is compressed, hot air derived from the engines, from the APU, or from a ground source. The air is routed to a common manifold. With the left and right isolation valves, the manifold can be split into three ducts, labeled as left, center, and right bleed air ducts. Only the pressure in the left and right ducts are indicated on the EICAS.

The following equipment is driven by bleed air from the respective ducts:

Left duct:

- Left wing leading edge flap drives
- Left wing thermal anti-ice
- Engine 1 & 2 nacelle thermal anti-ice
- Engine 1 & 2 thrust reverser sleeve drives *(not on PW engines)*
- Engine 1 & 2 starter motors
- Air driven hydraulic pumps 1 & 2 *(pump 2 electric on some aircraft)*
- Hydraulic systems 1 & 2 fluid reservoir pressurization
- Air conditioning pack 1

Center duct:

- Potable water pressurization
- Aft cargo heat
- Air conditioning trim air
- Cargo smoke detectors for vacuum generation by Venturi effect
- Air conditioning pack 2

Right duct:

- Right wing leading edge flap drives
- Right wing thermal anti-ice
- Engine 3 & 4 nacelle thermal anti-ice
- Engine 3 & 4 thrust reverser sleeve drives *(not on PW engines)*
- Engine 3 & 4 starter motors
- Air driven hydraulic pumps 3 & 4 *(pump 3 electric on some aircraft)*
- Hydraulic systems 3 & 4 fluid reservoir pressurization
- Air conditioning pack 3

Air Conditioning:

Hot bleed air is ducted into three air conditioning packs where the incoming air is cooled and then fed into the cabin. The same hot bleed air also feeds the trim air system in which the incoming air remains uncooled. This hot trim air is fed into various cabin zones where it is individually mixed with the cool air from the packs. The mix ratios are determined by zone specific temperature selectors on the overhead panel. The packs provide a constant ventilation rate in the cabin; recirculation fans aid the packs in maintaining the rate. Recirculation, pack control, overheat protection, and fault protection are entirely automatic. Should a system fault occur, backup modes enable a simplified temperature control. Ozone converters are installed between the bleed air sources and the packs to reduce ozone concentration in the cabin. Aside from external bleed air, the aircraft can also be supplied by external conditioned air. External conditioned air supplies the cabin directly so that the packs and the bleed air system can be shut down.

(In the simulator, external bleed air and external conditioned air can be activated on ***Instructor*** *>* ***Situation*** *>* ***Service****.)*

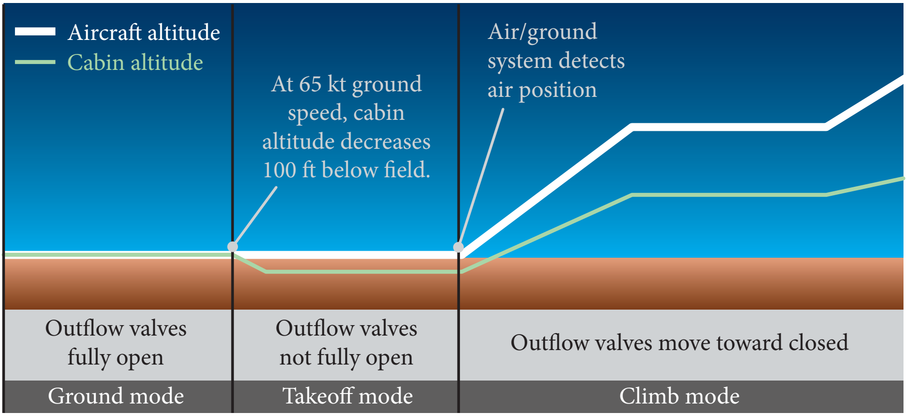
Cabin Pressurization:

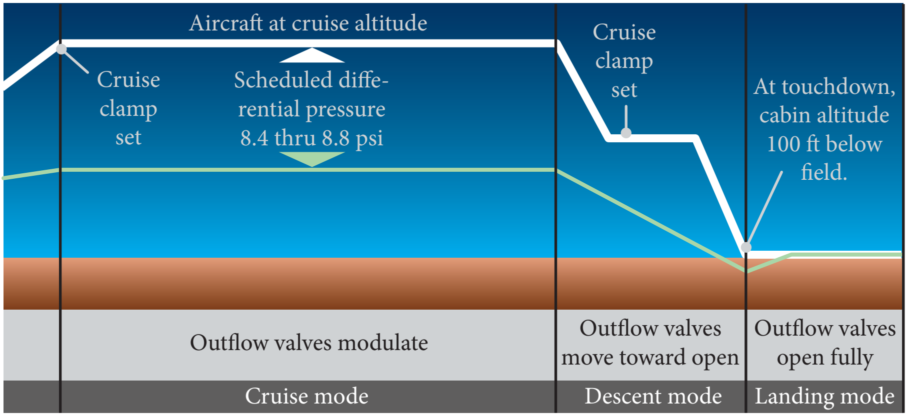
When the packs supply the cabin with conditioned air, they also build up cabin pressure. However, only two air flow rates are available—high flow and normal flow—, thus the packs cannot fine-tune the pressurization. For exact regulation, two variable outflow valves are installed at the rear of the cabin: the wider they open, the more cabin air will discharge overboard. In other words, when the outflow valves are completely open, the cabin altitude is almost equivalent to the aircraft altitude. The outflow valves are automatically adjusted by one of the two cabin altitude controllers. Manual adjustment is possible as well. Should the cabin-to-ambient pressure differential become abnormally high, safety relief valves will open: two of them in the lower fuselage protect against excessive overpressure, another four in the two cargo doors protect against excessive underpressure.

PNF

In the simulator, after takeoff when CLB thrust is set, pack selectors may be set to NORM by the virtual Pilot Non-Flying (PNF) to relieve the flying pilot in a one-crew simulator session. The PNF can be deactivated on **Instructor** > **Situation** > **Human** > **Pilot** by clearing the checkbox **Performs silent tasks**.

Typical Flight Profile:





The **cruise clamp** signal causes the packs to switch to normal flow (if no other condition is requesting high flow). During climb and descent, high flow is applied. The cruise clamp is set and latched once the aircraft is above 25000 ft, and either the aircraft altitude does not vary by more than ±100 ft for 45 seconds or is within 100 feet of the FMC CRZ ALT. It is also set in descent when the aircraft altitude does not vary by more than ±250 ft for 2 minutes. The cruise clamp is reset when the aircraft is on the ground.

SYSTEM ANALYSIS

In the simulator, the cruise clamp status can be checked on **Instructor** > **Analysis** > **Miscellaneous**. The cruise clamp status is also accessible through the simulator's main network.

EICAS Messages:

WARNING MESSAGES (accompanied by warning light and siren sound)		
CABIN ALTITUDE		cabin altitude exceeds 10000 ft

CAUTION MESSAGES (accompanied by caution light and beeper sound)		
BLD DUCT LEAK ()		leak or overheat in bleed air duct (L, C, or R)
CABIN ALT AUTO		input loss from both pressure controllers OR both fail OR both outflow valves in manual control mode
EQUIP COOLING		low flow OR smoke OR overtemperature OR fan failure OR valve disagreement in equipment cooling system *[inhibited when in override mode]*

ADVISORY MESSAGES		
BLD () OVHT/PRV	SYS FAULT LIGHT	bleed air overheat switch actuated commanding engine (1, 2, 3, or 4) PRV* or HPSOV to close OR PRV* failed closed *[* for RR engines: FWSOV instead of PRV]*
BLEED ()	SYS FAULT LIGHT	engine (1, 2, 3, or 4) PRV* failed to close OR HPSOV failure *[* for RR engines: FWSOV instead of PRV]*
>BLEED () OFF	OFF LIGHT	engine (1, 2, 3, or 4) PRSOV closed while engine running AND bleed commanded off
>BLEED ISLN APU	VALVE LIGHT	APU bleed isolation valve disagrees with switch position
BLEED ISLN ()	VALVE LIGHT	isolation valve (L or R) disagrees with switch position
>EE CLNG CARD		no valid ARINC 429 data OR card failure *[inhibited in flight]*
LANDING ALT		cabin pressure controller landing altitude disagrees with FMC selected landing altitude
OUTFLOW VLV ()		outflow valve (L or R) automatic control failed OR in manual control mode

(continued next page)

EICAS Messages:

(continued)

ADVISORY MESSAGES		
PACK ()	SYS FAULT LIGHT	pack system fault OR valve failure OR overheat
PACK CONTROL	SYS FAULT LIGHT	both pack temperature controllers A and B fail
PRESS RELIEF		pressure relief valve actuates while all packs on
>TRIM AIR OFF		pack overheat OR master trim air valve closed *[temperature control in backup mode]*

MEMO MESSAGES		
PACK () OFF		one pack (1, 2, or 3) is manually selected off *[inhibited when multiple packs are off]*
PACK 1+2 OFF		pack 1 and 2 are manually selected off *[inhibited when all packs are off]*
PACK 1+3 OFF		pack 1 and 3 are manually selected off *[inhibited when all packs are off]*
PACK 2+3 OFF		pack 2 and 3 are manually selected off *[inhibited when all packs are off]*
PACKS HIGH FLOW		pack high flow switch is on
PACKS OFF		all packs are manually selected off

STATUS MESSAGES		
BLD DUCT LEAK ()		leak or overheat in bleed air duct (L, C, or R)
BLD () OVHT	SYS FAULT LIGHT	bleed air overheat switch actuated commanding engine (1, 2, 3, or 4) PRV/FWSOV or HPSOV to close
BLEED ASCTU ()		air supply control and test unit (channel A or B) failed OR no valid ARINC 429 data
A BLEED () CLOSED	SYS FAULT LIGHT	bleed air valves engine (1, 2, 3, or 4) closed by strut overheat protection *[RR engines only]*
CAB ALT AUTO ()		cabin altitude controller (channel A or B) failure OR no valid ARINC 429 data
CARGO HEAT BULK		bulk cargo heat system failed
CPCS AIR/GND		disagreement between primary and alternate air/ground signals of cabin pressure control system

(continued next page)

EICAS Messages:

(continued)

STATUS MESSAGES		
CPCS BACKUP SENS		cabin altitude backup data differ by more than 800 ft OR selected primary CPC failed
DUCT LEAK C LP ()		overheat or fault in loop (A or B) of bleed air duct C
DUCT LEAK L LP ()		overheat or fault in loop (A or B) of bleed air duct L
DUCT LEAK R LP ()		overheat or fault in loop (A or B) of bleed air duct R
ECS MISC CARD		environmental control system miscellaneous card failed OR no valid ARINC 429 data
EE CLNG BYPASS V		equipment cooling air bypass valve not in commanded position
EE CLNG CARD		equipment cooling card failed OR no valid ARINC 429 data
EE CLNG E6/E9 V		equipment cooling air E6/E9 valve not in commanded position
EE CLNG EXH FAN		equipment cooling air exhaust fan failed
EE CLNG GND EXH		equipment cooling air ground exhaust valve not in commanded position
EE CLNG INBD EXH		equipment cooling air inboard exhaust valve not in commanded position
EE CLNG SUP FAN		equipment cooling air supply fan failed
EE CLNG SUPPLY V		equipment cooling air supply valve not in commanded position
EQUIPMENT TEMP		equipment cooling air supply overtemperature
LAV-GALLEY FANS		both lavatory galley vent fans failed
LWR PRESS RELIEF		lower pressure relief valve open
OUTFLOW VALVE ()		outflow valve (L or R) automatic control failed OR under manual control
PACK ()	SYS FAULT LIGHT	pack system fault OR valve failure OR overheat
PACK CONTROL ()	SYS FAULT LIGHT	pack temperature controller (A or B) failed
RECIRC FAN LWR ()		lower (L or R) recirculation fan failed
RECIRC FAN UPR ()		upper (L or R) recirculation fan failed
UPR PRESS RELIEF		upper pressure relief valve open

Limitations in the Simulator:

The following messages are not included as the respective failures are not modeled: Advisory messages >TEMP CARGO A/C, TEMP CARGO HEAT, TEMP DEV CGO (), TEMP ZONE, and status messages BLEED FAMV ENG (), BLEED HP ENG (), BLEED LOSS APU, BLEED OVPRESS (), BLEED PRV ENG (), CAB EXH VLV (), CARGO A/C CARD, CARGO A/C VLV (), CARGO HEAT FWD (), CARGO ZONE TEMP, EE CLNG OVRD, EQUIP LOW FLOW, EQUIPMENT SMOKE, FLT DK LOW FLOW, HIGH ALT LDG, SMOKE/OVRD VLV, ZONE TEMP.

Automatic Flight

System Overview:

Automatic flight is accomplished using two independent systems:

- **The autothrottle system (A/T)**
- **The autopilot & flight director system (AFDS)**

The **A/T** is part of the flight management system (FMS). The FMS controls an electric servo motor which moves the thrust levers on the flight deck. The FMS can also send roll and pitch commands to the AFDS for LNAV and VNAV guidance.

The **AFDS** includes three flight control computers designated as FCC L, C, and R. For safety reasons, each FCC is linked with a different power source and an individual hydraulic system. During automatic approach, landing, rollout, or go-around, two or three FCCs simultaneously control the ailerons, elevators and rudders. In all other flight phases, only one FCC can be active at a time and automatic rudder control is inactive (yaw dampers keep working; they are not part of the AFDS). Three autopilot engage switches labeled as CMD L, C, R allow the crew to select an FCC for autopilot operation. The FCCs can also compute the flight director (F/D) commands that are visualized on the instruments by crossbars or V-bars. That FCC which provides the F/D computing can be selected individually for the left seat and right seat instruments using the onside FCC source selector. To compute roll and pitch commands, the FCCs receive information from the inertial reference system (IRS), from air data computers (ADCs), and from ILS receivers. Roll and pitch commands from the FMS for LNAV and VNAV are carried over directly. Finally, the FCCs use these commands to compute flight control target positions that are set by the autopilot servos. When the elevator is out of neutral for a longer period of time, the FCC autotrims the horizontal stabilizer. Aileron trim and rudder trim are not automatic.

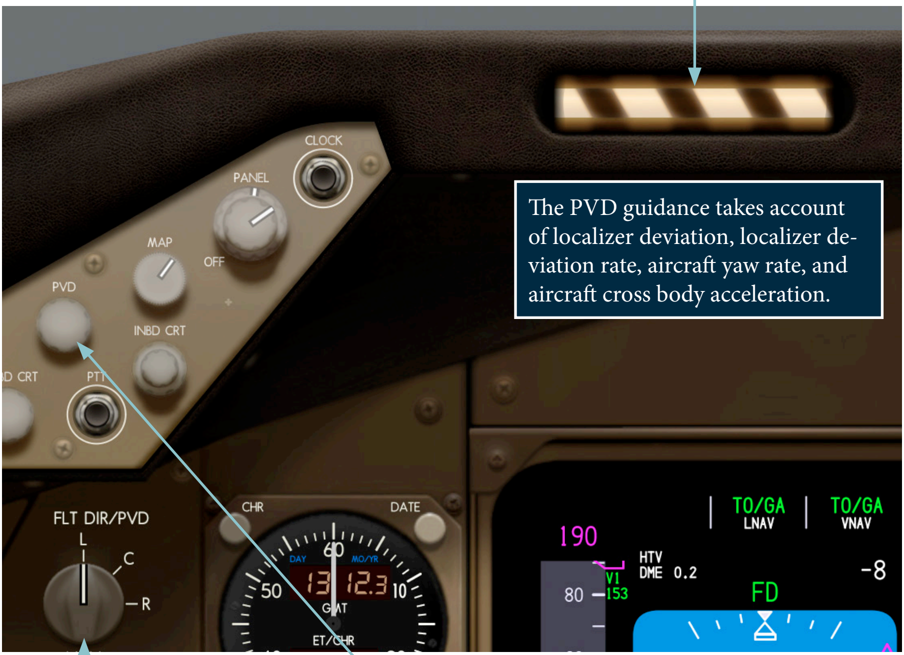
The crew uses the **mode control panel (MCP)** to manage AFDS modes and A/T modes. For redundancy, the MCP includes two identical electronic boards, each powered by a dedicated bus. Whenever the crew initially engages an autopilot or an F/D, the system autoselects certain modes for both the roll axis and the pitch axis; it is not possible to steer one axis manually and the other automatically. To disengage any roll or pitch mode completely, all autopilots must be disconnected and both F/D switches must be set to OFF. This method is especially important to remember when both the LOC mode and the G/S mode are engaged; the only alternative method to disengage this mode pair is pushing a TO/GA switch. In all other cases, a mode can be disengaged by selecting another mode. In normal flight, the crew either engages both the A/T and the AFDS, or disengages both. Nevertheless, A/T operation does not require any AFDS mode to be engaged. Vice versa, AFDS operation does not require any A/T mode to be engaged.

FCC Sources and PVD System:

PVD - Paravisual display (Captain's PVD, F/O's PVD)
(normally not on all aircraft; in the simulator on all aircraft)

The PVD is a steering director for use during the takeoff roll, based on the tuned localizer. The stripes keep moving left or right whenever the aircraft is not on a suitable intercept track to the localizer. When enabled by the PVD switch, the display will operate when all of these conditions are true:

+ Radio altitude is below 5 feet.
+ Aircraft is within 2° of localizer course, or within 3.2° when leaving 2° sector.
+ Localizer intercept angle is less than 45°.
+ Any FCC is operative (selected FCC source is preferred source, other FCCs are backups).
+ ROLLOUT autopilot mode is disengaged.
+ IRS is aligned.



The PVD guidance takes account of localizer deviation, localizer deviation rate, aircraft yaw rate, and aircraft cross body acceleration.

FCC source selector (Captain's source, F/O's source)
Selects flight control computer source of onside flight director and onside PVD.

L, C, R Left, center, right FCC.

PVD switch and dimmer (Captain's PVD, F/O's PVD)

Push	Unshutters PVD and starts 5-second-test. After test, PVD will be enabled to be shuttered and unshuttered by system logic.
Second push	Shutters PVD.
Rotate	Dims PVD lighting.

Mode Annunciation on PFD:

Engaged A/T mode

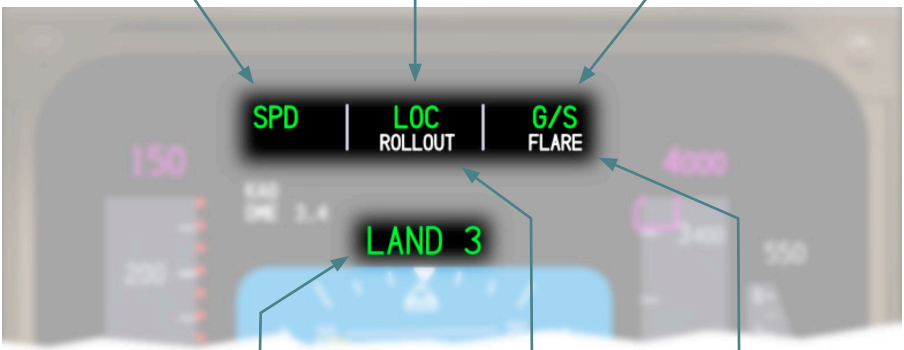
Possible modes:
- HOLD
- IDLE
- SPD
- THR
- THR REF

Engaged roll mode

Possible modes:
- ATT
- HDG HOLD
- HDG SEL
- LNAV
- LOC
- ROLLOUT
- TO/GA

Engaged pitch mode

Possible modes:
- ALT
- FLARE
- FLCH SPD
- G/S
- VNAV ALT
- VNAV PTH
- VNAV SPD
- V/S
- TO/GA



AFDS status

Possible status:
- FD
- CMD
- LAND 3
- LAND 2
- NO AUTOLAND
- TEST *(not in simulator)*

Armed roll mode

Possible modes:
- LNAV
- LOC
- ROLLOUT

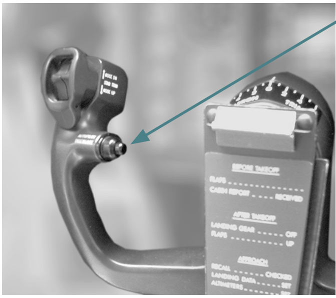
Armed pitch mode

Possible modes:
- VNAV
- G/S
- FLARE

Boxed words
When a mode or AFDS status has changed, a box is drawn around the mode or status word for 10 seconds.

Struck-through words
When a roll or pitch mode fault is detected, an amber line is drawn over the green mode word.

Autopilot Disengagement:

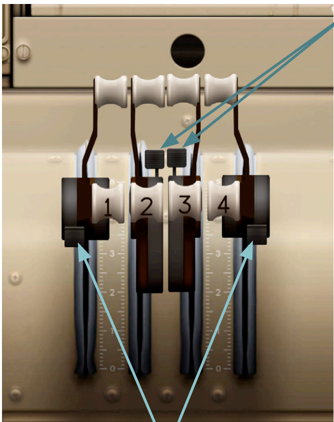


Captain's yoke, not displayed in the simulator.

Autopilot disengage switch
(Switch is not visualized in simulator; function is assigned to A-key on PC keyboard. It can also be assigned to USB buttons or to networked hardware.)

Push If any autopilot is engaged:
Disengages all autopilots. EICAS warning message >AUTOPILOT DISC appears and wailer sounds continuously. Warning cannot be removed by master warning reset switch.
If any autopilot has been disengaged manually or automatically:
Removes warning message >AUTOPILOT DISC and silences the wailer.
*(Warning can be cleared also on **Instructor > Situation > Service: Erase latched messages**.)*

Autothrottle Controls:



TO/GA switch

Push When on ground for takeoff:
Engages A/T in THR REF mode and, if GPS is not available, sets FMC computed position to threshold position of entered database runway, or to displaced threshold if entered. Activates TO/GA roll and pitch modes for takeoff.
When airborne, and if flaps are out or if G/S or FLARE pitch mode is engaged:
If thrust limit is D-TO, TO 1, or TO 2, activates TO thrust limit. Engages TO/GA roll and pitch modes. Engages A/T in THR mode for 2000 fpm climb rate; or, when THR and TO/GA already engaged, engages THR REF for climb with thrust at reference limit (green line on EICAS).

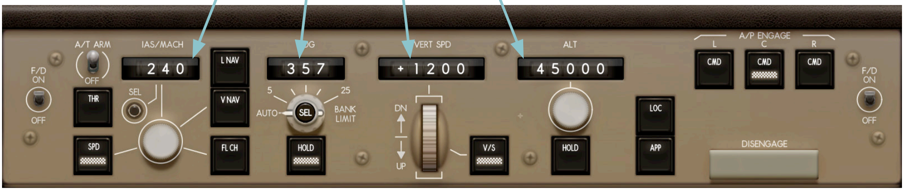
Autothrottle disconnect switch

Push If A/T is engaged:
Disengages A/T and keeps it armed. If not pushed again within one second, EICAS caution message >AUTOTHROT DISC will appear.
If A/T has been disengaged manually or automatically:
Removes EICAS caution message >AUTOTHROT DISC.

MCP:

A Mechanical version

Scrolling electromechanical indications
Backlight can be dimmed with the glareshield panel light control.



A LCD version

LCD indications
LCD brightness can be dimmed with the glareshield panel light control.
When the IND LTS test switch on the overhead panel is in the TEST position, all LCD segments activate and blink.

Brightness sensor
Senses the ambient light intensity and accordingly modulates the brightness of the LCD indications.

MCP:

Autopilot engage switch (left, center, right)

Push When all autopilots are disconnected and both F/D switches are off, engages the V/S pitch mode and, if the bank angle is greater than 5°, engages the ATT roll mode, else the HDG HOLD roll mode. The switch light illuminates, and the PFDs annunciate CMD; or, during ILS approach, LAND 3, LAND 2, or NO AUTOLAND. The selected autopilot will operate in the engaged pitch and roll modes.

Autopilot disengage bar

Push down (amber stripe in view) Disengages all three autopilots and prevents re-engagement.

Push up Allows autopilot engagement.

Flight director switch (left, right)

When all autopilots are disconnected and both F/D switches are off, setting an F/D switch to ON selects the initial roll and pitch modes as follows:

On the ground, arms TO/GA roll and pitch modes.

In flight, engages the V/S pitch mode and, if the bank angle is greater than 5°, engages the ATT roll mode, else the HDG HOLD roll mode.

ON Onside PFD annunciates the current modes and shows the F/D cross-bars or the V-bar to provide flight direction commands according to the current modes.

OFF Removes the mode annunciations and the crossbars or the V-bar from the onside PFD if no autopilot is engaged. Mode annunciations and crossbars or the V-bar will reappear when TO/GA modes are engaged through a TO/GA switch on the thrust levers.

PNF In the simulator, when the flying pilot moves the onside F/D switch, the other F/D switch may be moved to that same position by the virtual PNF (Pilot Non-Flying) to relieve the flying pilot in a one-crew simulator session. The PNF can be deactivated on **Instructor > Situation > Human > Pilot** by clearing the checkbox **Performs silent tasks**.

MCP:

A/T arm switch

ARM Enables EEC engine trim equalization.
Engages the A/T if VNAV is engaged, else arms the A/T which then may be engaged by pushing the VNAV, FLCH, SPD, or THR switch on the MCP, or a TO/GA switch on the thrust levers; it will remain engaged as long as all of the following conditions are true:
+ Three or four engines are running.
+ *PW, RR engines:* All four EECs are in NORM mode.
GE engines: All four EECs are in the same mode.
+ All four reverser levers are stowed.
+ A/T servo excitation is on (F/O's transfer bus is powered).
+ A/T servo power L or R is available (DC bus 1 or 2 is powered).
+ Selected master FMC is operative.
+ Selection of master FMC is not changed.
+ That ADC which feeds the Captain's selected FCC is operative.
+ Pitot-static and TAT probe heat power is available.

OFF Disables EEC engine trim equalization.
Disengages the A/T and prevents re-engagement.

Thrust switch

The switch is operative when the aircraft is in flight and has climbed above 400 ft during takeoff or go-around.

Push If the thrust limit is set to a takeoff limit:
Changes the thrust limit to the armed climb thrust limit.
If the thrust limit is not GA, or if the flaps are up and the pitch mode is not G/S:
Changes the thrust limit to CLB if all engines are running, else to CON.
If the pitch mode is not TO/GA, FLCH or VNAV:
Engages the A/T in THR REF mode, illuminates the switch light, and annunciates THR REF on the PFDs. The A/T will set the thrust to the thrust limit (green line on EICAS).

Speed switch

Push If the aircraft is in flight and has climbed above 400 ft during takeoff or go-around, and if the pitch mode is not TO/GA, FLCH or VNAV:
Engages the A/T in SPD mode, illuminates the switch light, and annunciates SPD on the PFDs. The A/T will maintain the speed displayed in the IAS/Mach window or, if limits are exceeded, the respective maximum or minimum speed. The selected reference thrust limit will not be exceeded.

MCP:

IAS/Mach select switch

Push Switches to Mach display if IAS is displayed and selected IAS is equivalent to M.4 or higher.
Switches to IAS display if Mach is displayed and selected Mach is equivalent to 399 KIAS or less.
Switch is inactive when display is blank or when on the ground.

IAS/Mach selector

Push If IAS/Mach window is not blank and VNAV is engaged:
Blanks IAS/Mach window and will inhibit manual selection of command speed; FMC will select command speed.
If IAS/Mach window is blank:
Unblanks IAS/Mach window, displays last FMC selected command speed, and will inhibit further FMC control to allow manual selection. If VNAV PTH pitch mode is engaged during idle descent, mode changes to VNAV SPD.

Rotate Selects command speed if IAS/Mach window is not blank. Selection is displayed in IAS/Mach window.

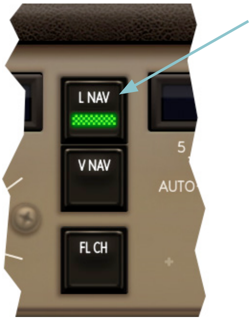
IAS/Mach window

Displays manually selected command speed when VNAV is disengaged or when MCP SPD is annunciated on FMC VNAV page, else window is blank.
Manually or FMC selected command speed is also displayed on PFDs.
Ranges from 100 to 399 KIAS, and from Mach 0.40 to 0.95.
In climb, switches from IAS to Mach when passing ca. Mach 0.84.
In descent, switches from Mach to IAS when passing ca. 310 KIAS.
200 is selected at MCP power-up.

A Mach display may have 2 or 3 digits.

PNF In the simulator, the virtual Pilot Non-Flying (PNF) may set the command speed when the autopilots are disengaged and: Voice-ATC gives speed instructions, or IAS/Mach window is not blank and aircraft is not climbing and flap lever is moved. The PNF can be deactivated on **Instructor** > **Situation** > **Human** > **Pilot** by clearing the checkbox **Performs silent tasks**.

MCP:



Lateral navigation switch

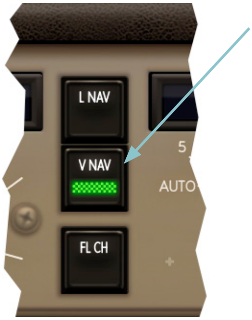
Push If LNAV mode is armed:
Disarms LNAV mode.
If LNAV is not armed and not engaged:
Arms LNAV mode.
When armed or engaged, switch light illuminates and PFDs annunciate LNAV in white (armed) or green (engaged).
Armed LNAV will automatically engage when all of the following conditions are true:

+ Aircraft is above 50 ft during takeoff, or above 400 ft in other flight phases.
+ Master FMC is operative.
+ An active route leg exists in FMC.
+ Aircraft is on intercept heading to active leg, or within 2.5 nm abeam the active leg.
+ Two or more engines are running.
+ IRS is aligned.
+ Pitot-static and TAT probe heat power is available.

When LNAV is engaged:
AFDS commands roll to follow active FMC route; or commands roll to maintain last heading after any of the following events:

- Last waypoint of active route is overflown.
- Last waypoint of route offset is overflown.
- Route discontinuity occurred in active leg.
- Route activation or modification is executed, and aircraft is not on intercept heading to, and not within 2.5 nm abeam the active leg.

MCP:



Vertical navigation switch

Push If VNAV mode is armed:
Disarms VNAV mode.
If VNAV is not armed and not engaged:
Arms VNAV mode.
When armed or engaged, switch light illuminates and PFDs annunciate VNAV in white (armed) or green (engaged).
Armed VNAV will automatically engage when all of the following conditions are true:
+ Aircraft is above 400 ft.
+ Two or more engines are running.
+ Master FMC is operative.
+ Gross weight, cost index, and cruise altitude are entered in FMC.
+ IRS is aligned.
+ Pitot-static and TAT probe heat power is available.

When VNAV SPD is engaged:
AFDS commands pitch to maintain command speed, while A/T is engaged in THR, THR REF, IDLE, or HOLD.
When VNAV PTH is engaged for descent:
AFDS commands pitch to maintain predicted descent profile while A/T is engaged in IDLE or HOLD (when on idle path) or SPD (when on non-idle path). When VNAV PTH on idle path exceeds maximum operating speed -11 kt (-16 kt in ECON mode), or command speed +10 kt when first speed restriction is passed, VNAV SPD will engage. When VNAV PTH on idle path drops below command speed -15 kt (or -10 kt when first speed restriction is passed), A/T will change to SPD mode.
When VNAV ALT or VNAV PTH is engaged in level flight:
AFDS commands pitch to maintain target altitude, while A/T is engaged in SPD.
When aircraft is between FMC target altitude and MCP altitude with any VNAV mode engaged:
VNAV ALT engages and commands pitch to maintain current altitude until conflict is cleared by resetting the MCP or FMC.
If command speed exceeds airspeed limit, VNAV uses respective minimum or maximum airspeed.

MCP:

Flight level change switch

Push Engages FLCH SPD pitch mode.
Switch light illuminates and both PFDs annunciate FLCH SPD.
If FMC has been controlling command speed:
Unblanks IAS/Mach window. If FMC selected command speed is valid, IAS/Mach window displays command speed, else current speed.
If FMC has not been controlling command speed:
If the selected command speed is lower than the current speed, IAS/Mach window displays the current speed.
If selected altitude is higher than current altitude:
If CRZ has been the reference thrust limit, limit changes to CLB; or to CON if any engine is out.
When FLCH SPD is engaged:
AFDS commands pitch to maintain the airspeed displayed in IAS/Mach window; or, if limits are exceeded, the respective minimum or maximum airspeed. A/T engages in THR mode which adjusts the aircraft's vertical speed so that the flight level change will take 2 minutes (or less if the minimum vertical speed of 500 fpm is to be maintained); if the level change is too great to be achieved in 2 minutes, throttles move to thrust reference limit for climb, or to idle for descent. A/T will engage in HOLD mode (to allow manual thrust adjustments) when the planned vertical speed is stabilized for descent, or when the pilot has moved the thrust levers in descent or climb. When approaching selected altitude, ALT pitch mode and SPD A/T mode engage.

MCP:

Bank limit selector (outer knob)
Selects bank limit for use with HDG SEL mode.

AUTO Limit is 15° if IAS is below V2+100 with flaps up or with gross weight above 308400 kg (680000 lb), or if IAS is below V2+10 while any engine is out, or if TAS is greater than 381 kt, else: Limit increases 15° to 25° with TAS decreasing 381 to 332 kt. Below 200 ft radio altitude, limit is 8°.

5 to 25 Limit is fixed as selected.

Heading selector (inner knob)

Rotate Selects heading for HDG SEL roll mode. Selection is shown in heading window. When rotating through 180° relative from current heading, command logic will maintain initial turn direction.

Heading select switch

Push Engages HDG SEL roll mode. HDG SEL is annunciated on PFDs. AFDS will command roll to turn to and maintain selected heading. AFDS will initially command turn into direction of shortest distance to selected heading that is present at mode engagement. Sequences active FMC leg if VECTORS is in first or next leg.

Heading window
Displays selected heading. Selection is also shown on PFDs and NDs.
When LOC roll mode engages, selected heading changes to localizer front course entered in FMC.
000 is selected at MCP power-up.

Heading hold switch

Push Engages HDG HOLD roll mode. Switch light illuminates and HDG HOLD is annunciated on PFDs. AFDS will command roll toward wings level. In the moment when within 3° of wings level, current heading will be copied to target heading; then AFDS will command roll to hold that target heading.

PNF In the simulator, the virtual Pilot Non-Flying (PNF) may select the heading when all autopilots are disengaged and Voice-ATC gives vectors. The PNF can be deactivated on **Instructor** > **Situation** > **Human** > **Pilot** by clearing the checkbox **Performs silent tasks**.

MCP:

Vertical speed window
Displays selected vertical speed for V/S pitch mode. Selected value is also shown on PFDs. Range is -8000 to +6000 fpm in 100 fpm increments. Display is blank when V/S pitch mode is disengaged.

Vertical speed selector

Rotate Selects vertical speed for V/S pitch mode. Selection is shown in vertical speed window.
When selected value is zero, V/S pitch mode operates in altitude hold submode; internal target altitude for this is fixed and set to the current *pressure altitude* that is present at first level-off, and altitude hold will not follow any EFIS baro resettings.

Vertical speed switch

Push If ALT is engaged, or if aircraft is descending and TO/GA pitch mode is engaged, sets selected V/S to 0 fpm; otherwise each push sets selected V/S equal to current aircraft V/S.
If FLCH or VNAV is engaged, and A/T is engaged but not in SPD mode, A/T mode changes to SPD.
Engages V/S pitch mode. Switch light illuminates, vertical speed window unblanks, and both PFDs annunciate V/S.
Airspeed limits may be exceeded as the V/S mode will not provide airspeed protection; AFDS pitch command will aim at selected vertical speed.
When approaching selected altitude, V/S operates in altitude acquire submode, guiding along a smooth altitude capture profile. When reaching selected altitude, and selection has not been changed for 2 seconds, pitch mode changes to ALT.

MCP:

Altitude window
Displays selected altitude.
Selected value is shown on PFDs as well, and is also reference for altitude alert.
Range is 0 to 50000 ft in 100 ft increments.
10000 is selected at MCP power-up.

Altitude selector

Rotate Selects altitude for altitude capture in TO/GA, VNAV, FLCH or V/S mode. Selection is shown in altitude window.

Push If VNAV ALT is engaged and aircraft is not at selected altitude, changes mode to VNAV SPD or VNAV PTH.

Else, in VNAV CLB or DES phase, each push deletes next waypoint constraint between aircraft and selected altitude; VNAV, if engaged, will initiate climb or descent toward new target altitude.

Copies selected altitude to FMC CRZ ALT if all of these conditions are true:
+ VNAV is engaged.
+ Aircraft not within 200 nm of T/D.
+ FMC in CLB phase and selected altitude is above FMC CRZ ALT; or in CRZ phase and selected altitude is not equal to FMC CRZ ALT.

If within 50 nm of T/D, and selected altitude is below FMC CRZ ALT, VNAV changes to DES phase and, if engaged, will command pitch for a shallow early descent.

Altitude hold switch

Push Engages ALT pitch mode.
Switch light illuminates and both PFDs annunciate ALT. If FLCH or VNAV has been engaged before, and A/T is engaged but not in SPD mode, A/T mode changes to SPD.
If aircraft altitude is within ±50 ft of selected altitude:
Each push copies *selected altitude* to target altitude which will be subject to EFIS baro resettings.
Else:
Each push copies current *pressure altitude* to target altitude, and altitude hold will not follow any EFIS baro resettings.
AFDS will command pitch to return to and hold target altitude.

PNF

In the simulator, the virtual Pilot Non-Flying (PNF) may set and push the altitude selector according to Voice-ATC instructions when all autopilots are disengaged, or for FMC step climbs. The PNF can be deactivated on **Instructor > Situation > Human > Pilot**: checkbox **Performs silent tasks** and checkbox **Sets S/C alt if VNAV PTH engaged**.

MCP:

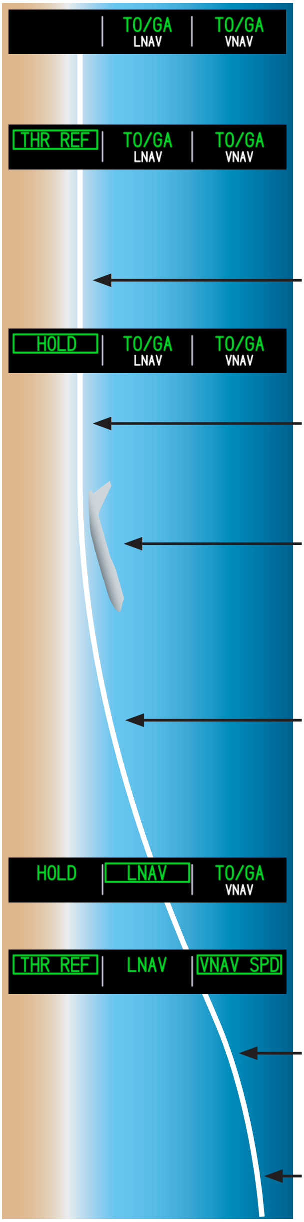
Localizer switch

Push If LOC mode is armed:
Disarms LOC mode.
If LOC is not armed and not engaged:
Arms LOC mode.
Armed LOC mode will automatically engage when aircraft intercept track is within 120° of localizer course and when relation between intercept track, localizer deviation, and groundspeed is adequate for timely localizer capture.
When armed or engaged, switch light illuminates and PFDs annunciate LOC in white (armed) or green (engaged).
When LOC is engaged, AFDS commands roll to follow localizer course.

Approach switch

Push If LOC and G/S modes are armed:
Disarms LOC and G/S modes.
If LOC is not armed and not engaged:
Arms LOC mode.
If G/S is not armed and not engaged:
Arms G/S mode.
Switch light illuminates when G/S is armed or engaged. LOC and G/S are annunciated on PFDs in white (armed) or green (engaged).
Armed LOC mode will automatically engage when aircraft intercept track is within 120° of localizer course, and when relation between intercept track, localizer deviation, and groundspeed is adequate for timely localizer capture.
Armed G/S mode will automatically engage when aircraft intercept track is within 80° of localizer course and aircraft has captured the glideslope. Either the localizer or the glideslope may be captured first.
If any autopilot is engaged, arms other two autopilots (illuminating all CMD lights) for automatic engagement which will occur when the aircraft is below 1500 ft radio altitude and the LOC and G/S modes are engaged.
When LOC is engaged, AFDS commands roll to follow localizer course.
When G/S is engaged, AFDS commands pitch to follow glideslope.
When LOC and G/S are engaged, modes can only be disengaged by pushing a TO/GA switch, or by disconnecting all autopilots and setting both F/D switches to OFF.

Takeoff Operation:



Preflight: F/D switches are set to ON. LNAV and VNAV are armed. AFDS commands circa 8° pitch attitude (not for use with autopilot).

Takeoff clearance: Pilot sets thrust levers to vertical position and checks engine parameters on EICAS. If parameters are normal, pilot pushes TO/GA switch which engages A/T in THR REF mode. A/T moves throttles to takeoff thrust limit.

50 KIAS: TO/GA switch is inhibited until after liftoff.

65 KIAS: A/T changes to HOLD mode to allow manual thrust control if necessary.

100 KIAS: FMC stores the current barometric altitude as a runway elevation reference for later use re LNAV/VNAV engagement, flap acceleration and thrust reduction.

Liftoff: AFDS starts commanding the roll to maintain runway track, and the pitch to maintain the airspeed that was recorded when pitch passed 2°, +10 kt; or to maintain V2+10 if that is greater.

If current airspeed remains above target airspeed for 5 seconds: Target airspeed is reset to current airspeed, but not greater than V2+25.

In case of engine failure: Target airspeed remains between V2 and V2+10.

50 feet above runway elevation: Armed LNAV engages, and FMC starts commanding the roll to follow active FMC route.

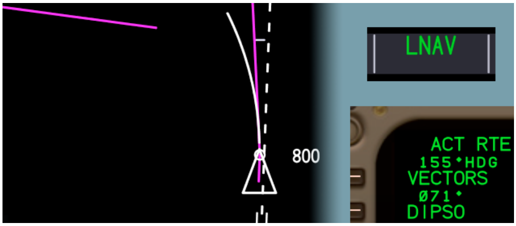
400 feet above runway elevation: Armed VNAV engages, and A/T changes to THR REF mode.

Flap acceleration height: VNAV starts using a target speed of V2+100, but not less than 250 kt; and not greater than flap limit speed or airport speed restriction, whichever is lower.

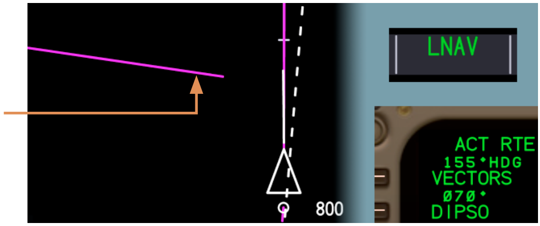
Thrust reduction point: (Above, below, or at flap acceleration height.) FMC activates armed climb thrust limit.

LNAV VECTORS Operation Example:

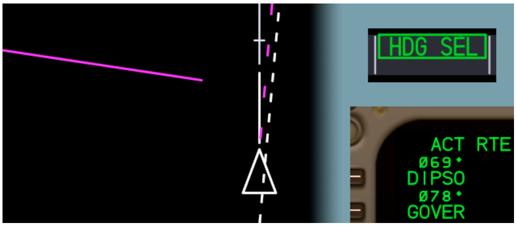
VECTORS is in the active FMC route leg and commands a specific heading. LNAV commands the roll to maintain that heading. The track over ground will be wind dependent.



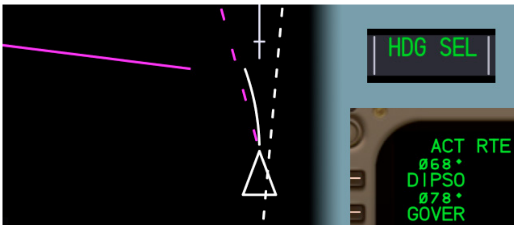
If an intercept course to the next waypoint is not defined, the FMC provides a moving intercept leg whose starting point is always placed such that the aircraft can at any time join it using the current TAS related minimum turn radius.



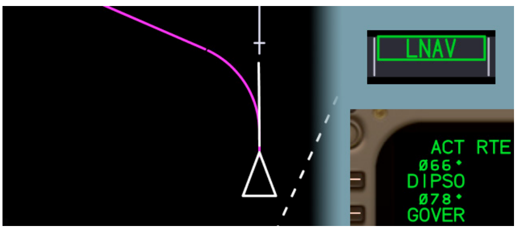
The pilot sequences the VECTORS leg by pushing the HDG SEL knob on the MCP. The FMC keeps providing that moving intercept leg to the active waypoint if an intercept course is not defined.



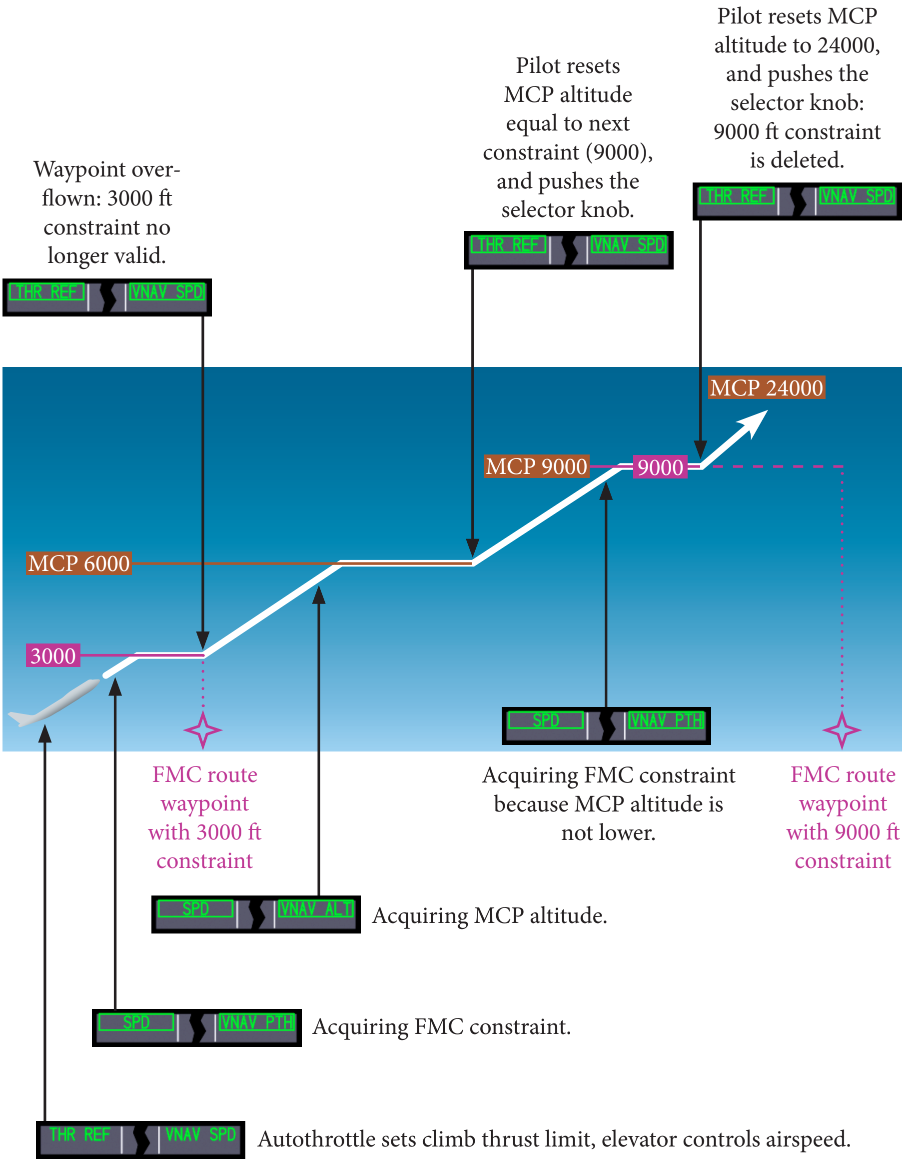
From time to time, the pilot selects new headings on the MCP according to ATC instructions.



Finally, ATC instructs to fly direct to the active waypoint. The pilot arms LNAV which promptly engages. The intercept leg stops moving, and the intercept turn becomes visible. LNAV will follow the magenta routing.



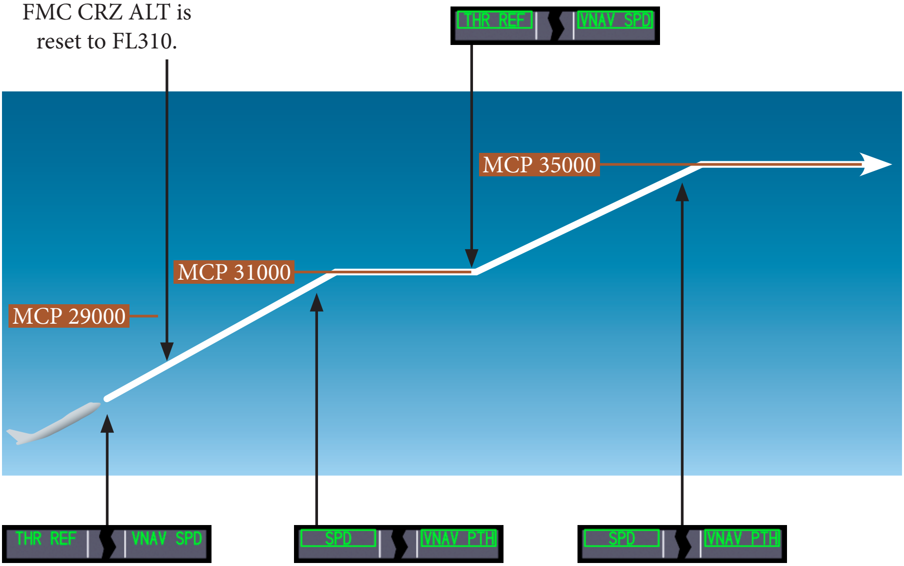
VNAV Climb Operation Example:



VNAV Cruise Operation Example:

Before reaching FL290, recleared to FL310 by ATC. Pilot resets MCP altitude from 29000 to 31000 and pushes the selector knob: FMC CRZ ALT is reset to FL310.

Recleared to FL350 by ATC. Pilot resets MCP altitude from 31000 to 35000 and pushes the selector knob: FMC CRZ ALT is reset to FL350.



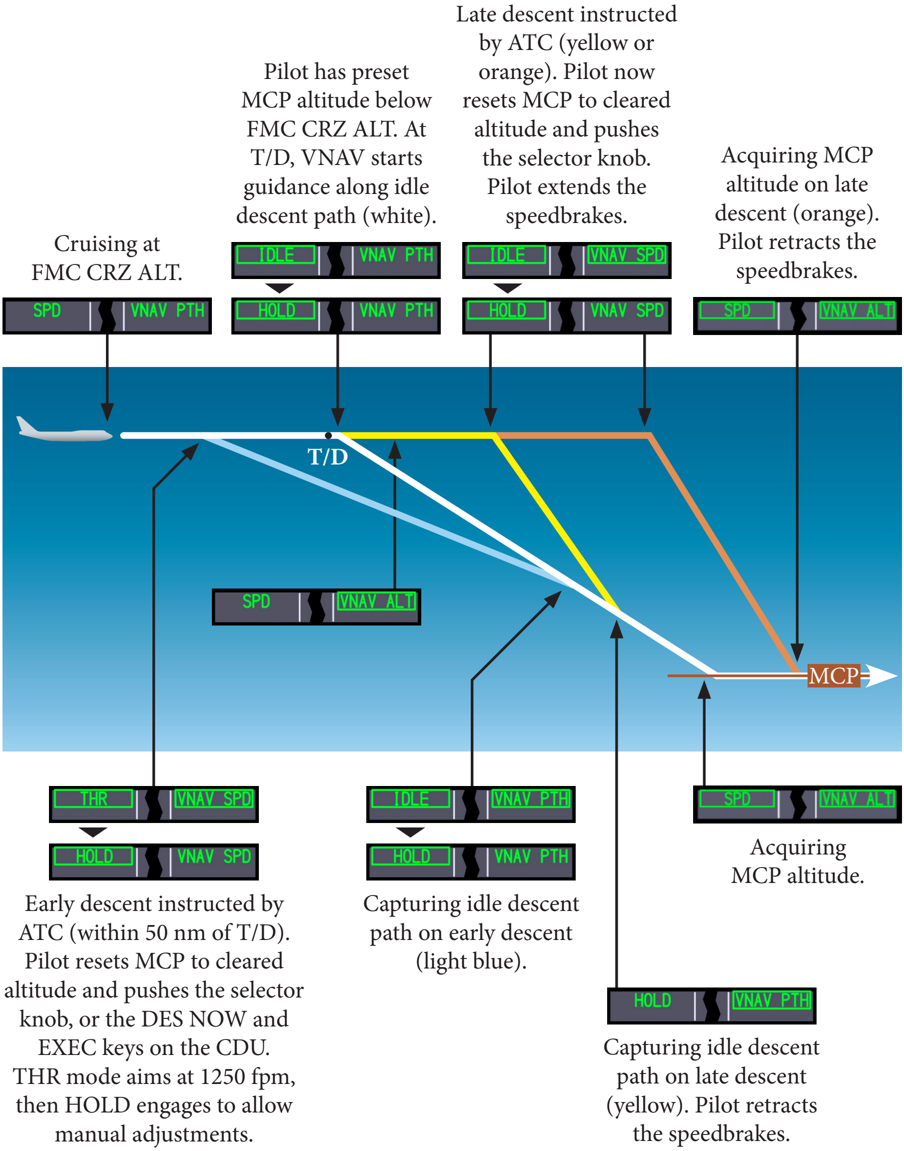
Cleared by ATC to climb to FL290. MCP and FMC CRZ ALT are set to FL290. Autothrottle sets climb thrust limit, elevator controls airspeed.

Acquiring FMC CRZ ALT.

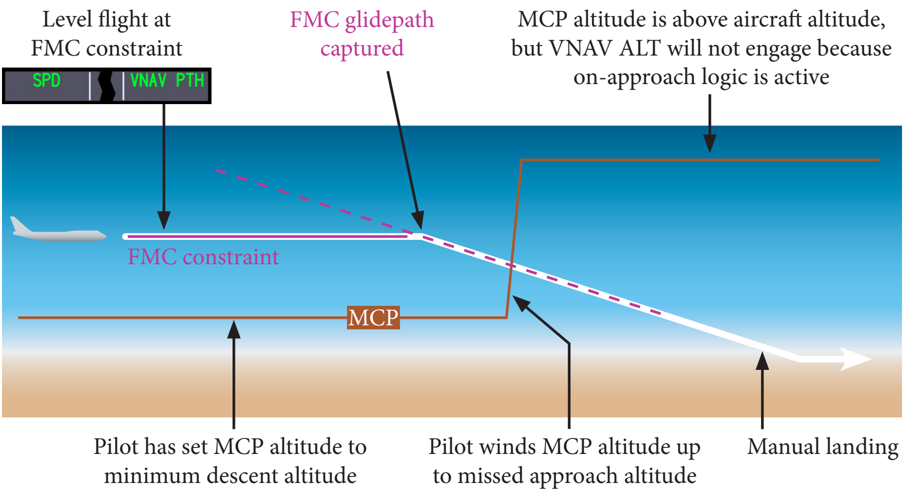
Acquiring FMC CRZ ALT.

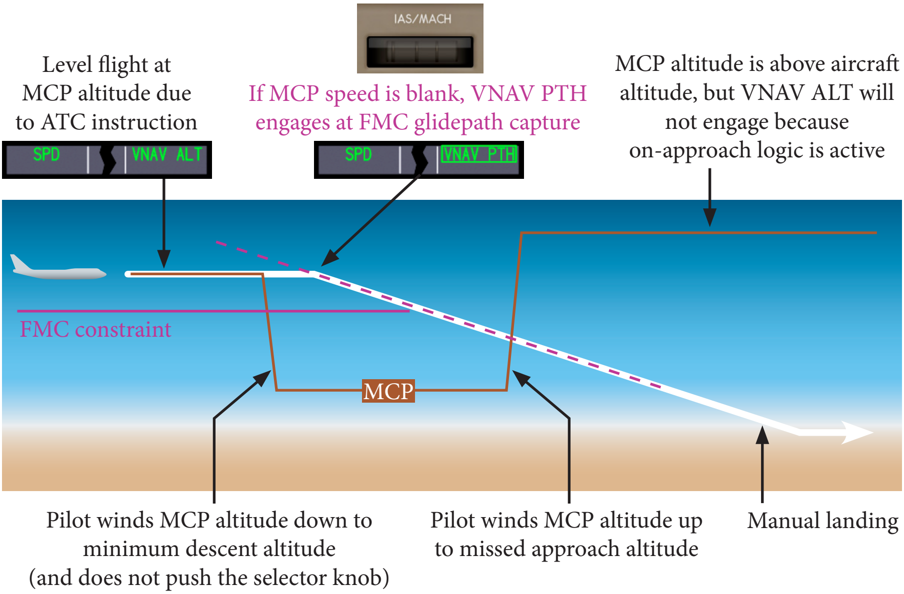
FMC cruise altitudes (CRZ ALT) are displayed on CDUs:

VNAV Descent Operation Examples:

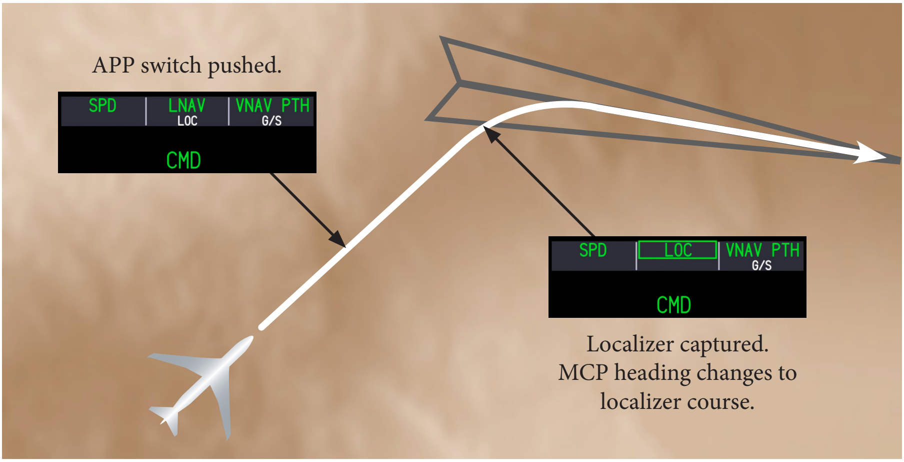


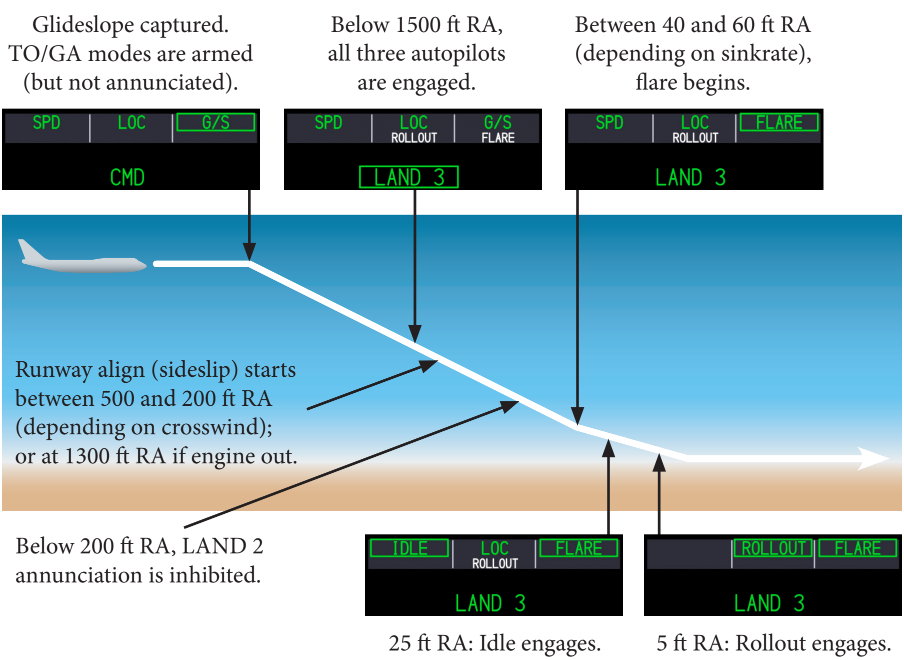
VNAV Approach Operation Examples:



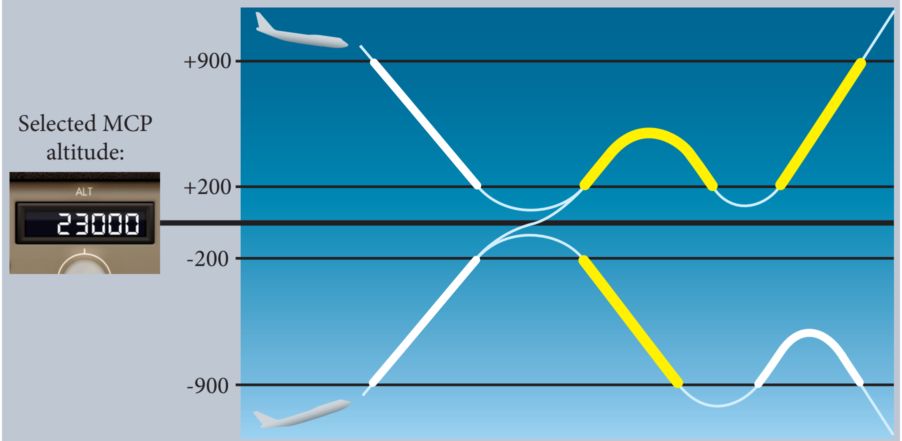


Autoland Operation:





Altitude Alert:



On the PFDs an amber box is displayed around the current altitude, and the EICAS caution message >ALTITUDE ALERT appears.

The alert can be reset by pushing a master warning reset switch, or by selecting another altitude.

The alert is inhibited for 2 seconds after the last altitude selection; it is also inhibited when both of these conditions are true:

+ Park brake lever released.
+ Landing flaps selected and gear down, or G/S or FLARE engaged.

On the PFDs a white box is displayed around the selected altitude and the current altitude.

A The C-chord, if installed, sounds when entering the 900 ft block.

Normal indications.

EICAS Messages:

WARNING MESSAGES (accompanied by warning light and wailer sound)		
>AUTOPILOT DISC		all engaged autopilots have been disconnected

CAUTION MESSAGES (accompanied by caution light and beeper sound)		
>ALTITUDE ALERT		deviation from selected altitude by 200 ft or more
>AUTOPILOT		engaged autopilot is not receiving required inputs
>AUTOTHROT DISC		autothrottle has been disconnected or has failed to disconnect
>NO AUTOLAND		multichannel approach selected and loss of autoland system between 1500 and 200 ft RA
>NO LAND 3		multichannel approach selected and degradation of autoland system between 1500 and 200 ft RA

ADVISORY MESSAGES		
>NO AUTOLAND		loss of autoland system before multichannel approach is selected
>NO LAND 3		degradation in autoland system before multichannel approach is selected
>PVD SYS ()		fault in PVD (CAPT or F/O) while selected on

MEMO MESSAGES		
PVD () ON		one PVD (CAPT or F/O) is on and no fault exists
PVD BOTH ON		both PVDs are on and no fault exists

STATUS MESSAGES		
ALT ALERT SYS		input loss or failure in altitude alert system
A/P SINGLE SYS		autopilot revisionary configuration due to loss of autopilot redundancy
NO AUTOLAND		autoland system not available
NO LAND 3		degradation in autoland system
PVD SYSTEM ()		fault in PVD (CAPT or F/O)

Auxiliary Power

For APU bleed air system, refer to chapter **Air Systems**.
For APU electrical system, refer to chapter **Electrical**.
For APU fire protection, refer to chapter **Fire Protection**.
For APU fuel system, refer to chapter **Fuel System**.

System Overview:

The auxiliary power unit (APU) is a gas turbine driven system installed in the tail cone of the aircraft. The APU can provide bleed air and electrical power. However, it is not designed to provide electrical power in flight. After takeoff, bleed air can be used for one air conditioning pack up to 15000 feet. On the ground, before or after engine start, the APU is able to supply bleed air to all three packs.

To start and operate the APU, the BATTERY switch on the electrical panel must be in the ON position. The pilot starts the APU by holding the APU selector in the START position for approximately two seconds. During the start process, the main battery and the APU battery are used, and the APU battery charger is automatically disconnected. The main battery powers the APU fuel valve and the APU fire extinguisher, and provides standby power for the electronic APU controller (APUC). The APU battery powers the DC fuel pump, the APU fire detection system, the air inlet door, the starter (if not powered by a transformer rectifier), and it is the APUC's primary power source.

The APUC monitors and regulates all system parameters according to programmed standards. When the crew shuts down the APU by setting the APU selector to OFF, the APUC keeps the APU running unloaded for one minute. During this phase the APU cools down slowly to prevent thermal shock. In the event of a system fault, the APUC shuts down the APU automatically and entirely without executing the cooling phase.

Overhead Maintenance Panel:

A Toggle switch directions are aircraft specific; the NORM and TR functions may be in the upper or in the lower position.

Ground tests switch (guarded)

ENABLE

Allows maintenance engineers to test various aircraft systems when on the ground, mostly in combination with the central maintenance computer *(CMC; not modeled in the simulator)*. Also indicates APU data on the EICAS status display when the APU is not running; this feature is functional also in the air, and does not require CMC control.

NORM

Normal setting.

APU start source switch
(normally not on all aircraft; in the simulator installed on all models)

APU BATTERY

Start source is the APU battery.

TR

Start source is a transformer rectifier (TR) powered by AC bus 2 via the left utility bus. If this system is not powered, start source is the APU battery.

APU Control:

APU selector

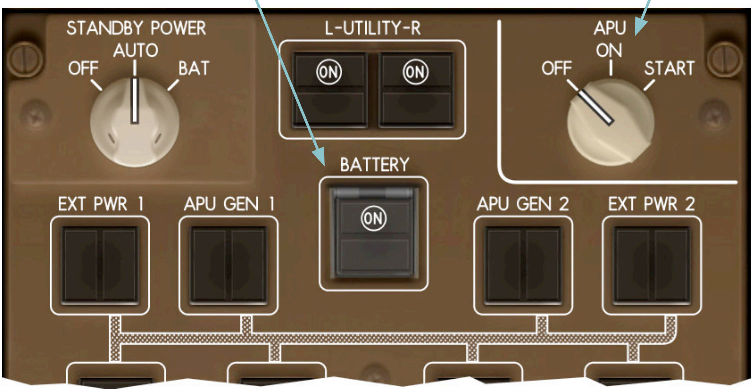
OFF Closes the APU bleed air isolation valve (if not closed by other means) and disconnects both APU generators. Starts the automatic APU shutdown program. After automatic fault shutdown, erases related EICAS messages unless the fault is an APU bleed duct leak.

ON Opens the APU air inlet door and the APU fuel valve for APU operation. Arms the APU bleed air isolation valve control. Activates an AC fuel pump system if AC power is available, otherwise a DC fuel pump.

START (spring loaded to ON position; hold for 2 seconds) Activates the automatic APU start program.

Battery switch

ON Enables APU operation. Connects the main battery and the APU battery with the respective battery busses.



EICAS Status Display:

Status display switch

First push Shows status display with APU indications on secondary EICAS display.

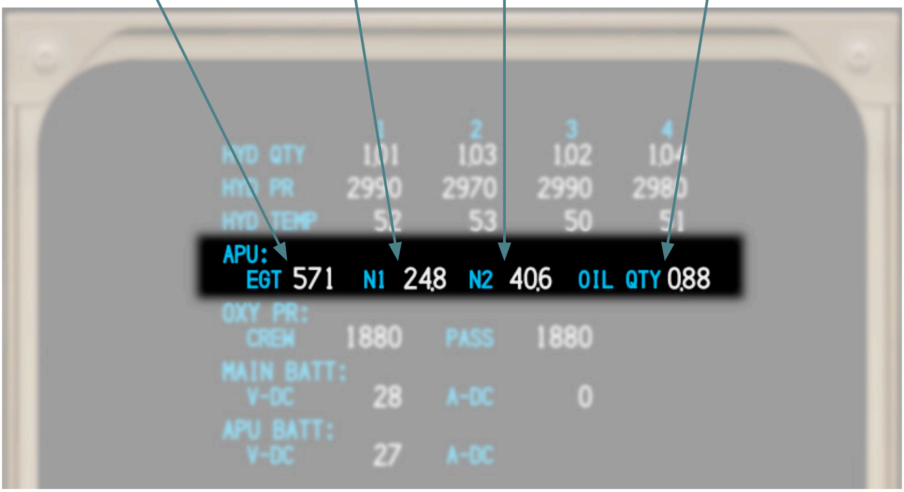
Second push Blanks secondary EICAS display.

Exhaust gas temperature (EGT) of APU in °C

APU N1 RPM in %

APU N2 RPM in %

APU oil quantity sensed in the oil tank. When the tank is full, indicates ca. 0.85 to 1.00 depending on the oil type in use. When the APU is running, some oil from the tank is distributed into other APU components, and the indicated quantity will be accordingly lower. RF (refill) is displayed when below 0.50; LO (low) when below 0.22.



EICAS Messages:

CAUTION MESSAGES (accompanied by caution light and beeper sound)		
APU FUEL		APU fuel pump has low pressure while commanded on OR APU fuel valve disagrees with commanded position

ADVISORY MESSAGES		
APU		{ APU selector in ON position AND automatic fault shutdown } OR { APU selector in OFF position AND no fault detected AND APU N1 RPM above 95% }

MEMO MESSAGES		
APU RUNNING		APU is running AND APU selector in ON position AND APU N1 RPM above 95%

STATUS MESSAGES		
APU		{ APU selector in ON position AND automatic fault shutdown } OR { APU selector in OFF position AND no fault detected AND APU N1 RPM above 95% }
APU FUEL VALVE		APU fuel valve disagrees with commanded position
APU STRT INHIBIT		APUC has detected a fault and inhibits the next APU restart

Limitations in the Simulator:

The messages APU DOOR, APU DUCT LEAK, and APU FUEL PUMP are not included as the respective malfunctions are not modeled.

Communications

System Overview:

Audio control panels (ACPs)

The flight deck is equipped with three ACPs installed on the aisle stand. They are designated as captain's ACP, first officer's ACP, and observer's ACP. On an ACP, a crew member can select those audio sources which are to be monitored on that crew member's headset or interphone speaker (the observer, however, has no dedicated speaker). Individual volume control of each audio source and each speaker is provided also. Transmitter selectors on the ACP are used to connect the respective crew member's microphones to one of the communication radios or interphone systems. The observer's ACP may be used as a captain's or first officer's ACP should either of those fail. In case of a fault in the audio management unit (AMU), VHF L can be directly connected to the captain's headset and microphones, so that VHF L audio will bypass the AMU.

Radio tuning panels (RTPs)

RTP is sometimes referred to as RCP (radio control panel). This book uses the term RTP only. There are three RTPs located on the aisle stand. They are designated as RTP L, C, and R. Any of the three RTPs can be used to tune the aircraft's five communication radios which are VHF L, C, R, and HF L, R. In normal operations, the RTPs should be configured so that each RTP only tunes its onside radios, that is: RTP L tunes VHF L and HF L; RTP R tunes VHF R and HF R; RTP C tunes VHF C. Otherwise, the white offside tuning lights on the affected RTPs illuminate to indicate the non-normal configuration. When all RTPs fail or are switched off, the communication radios remain operative; they just can no longer be tuned to another frequency.

Very high frequency (VHF) radios

Three VHF communication radios are installed, labeled as VHF L, C, and R. Any RTP can be used for tuning. VHF C is the only one of the three VHF radios that is linked with ACARS. When VHF C is set to 137.0 on the RTPs, VHF C will be actually tuned by the ACARS management unit (to frequencies below 137.0).

High frequency (HF) radios

Two HF radios are installed on the aircraft, labeled as HF L and HF R. Any RTP can be used to set the HF frequency, the HF sensitivity, and the modulation methods upper side band (USB) or amplitude modulation (AM).

(continued next page)

System Overview: *(continued)*

Satellite communication (SATCOM)

SATCOM is an optional system that provides data and voice communication via satellite. *(In the simulator, SATCOM is not installed.)*

Interphone

Interphone, in general, allows aircraft internal voice communication. It consists of the following subsystems: the *flight* interphone is used for communication within the flight deck, or between the flight deck and a station at the nose gear. The *service* interphone allows communication between maintenance specific locations inside the aircraft; it can also be connected to the *flight* interphone. The *cargo* interphone is used by load personnel on freighter and combi aircraft. On passenger aircraft, the *cabin* interphone connects the flight deck with flight attendant stations, including the passenger address system (PA). Chimes and lights may inform the flight crew of incoming calls. *(This can be demonstrated in the simulator by using the call buttons on* ***Instructor > Situation > Human > Calls****.)*

Cockpit voice recorder (CVR)

The CVR continuously records audio signals from the flight deck avionics, including all conversations picked up by the area microphone on the overhead panel. The CVR also records datalink traffic. *(The simulator software, however, does not actually record, and is not connected to any hardware microphones whatsoever.)*

Printer

A printer is installed on the aisle stand, allowing the crew to make printouts from various CDU controlled systems, such as ACARS or CPDLC. *(In the simulator, the virtual printout can be separated into a free floating desktop frame; refer to* ***Instructor > Preferences > Basics*** *and the checkbox* ***Allow paper sheet simulation****. The virtual paper roll will never get empty, and the simulator will not drive physical printers; however, it is possible to copy the paper text and paste it into other computer applications.)*

Aircraft communications addressing & reporting system (ACARS)

ACARS provides datalinks for receiving and transmitting digital information between ground stations and the aircraft. Information is transferred via satellite *(not in the simulator)* or via VHF. For VHF operations, ACARS can only use VHF C, and the pilot has to set VHF C on the RTPs to 137.0; this enables the ACARS management unit to tune VHF C as required (to frequencies below 137.0). This setting is also essential for CPDLC as CPDLC is based on ACARS.

ACP:

Transmitter selector
There are 10 transmitter selectors on an ACP; each selector contains a MIC light and a CALL light. The PA system, however, provides no call function.

Push (momentary action) Enables this ACP user's microphones to transmit on the selected radio or system. Only one can be enabled at a time. Pushing the CAB transmitter selector twice in quick succession will automatically call the flight attendants' priority station.
Resets the CALL light if the MIC light is not yet illuminated (if the MIC light is already illuminated, the CALL light can be reset by pushing a PTT switch, or by pushing another transmitter selector and then this selector).
Do not use VHF C for ATC communication when ACARS is in use.

MIC LIGHT Transmitter and receiver are selected. When selected, monitoring is possible also if the associated green receiver selection light is off.

CALL LIGHT A call has been received on the respective receiver, for example, from the ground crew (FLT), cabin crew (CAB), or HF radio by SELCAL.

Receiver selector & volume control
This function is associated with each of the 10 transmitter selectors.

Push (momentary action) Activates or mutes monitoring on the respective radio or system. However, muting is only possible when the associated MIC light is off.

Rotate Adjusts the monitor volume of the selected radio or system.

GREEN LIGHT Monitoring is activated by the *receiver selector* (monitoring can also be activated solely by the associated *transmitter selector* in which case the green light may be off).

(continued next page)

ACP: *(continued)*

Push-to-talk (PTT) switch
Switch is spring loaded to center position. When out of center, CALL light of selected transmitter is reset if it was illuminated, and transmission is in progress with this ACP user's microphone.

R/T Transmits on selected transmitter (transmits on FLT when FLT transmitter is selected).

INT Transmits on FLT interphone system only, regardless whether FLT transmitter is selected or not.

Speaker selector & volume control
Operative only when associated with the captain's or first officer's speaker; there is no dedicated speaker for the observer.

Push (momentary action) Activates or mutes monitoring on this ACP user's interphone speaker.

Rotate Adjusts speaker volume.

GREEN LIGHT Speaker monitoring is active.

Navaid audio filter selector

V (voice) Only voice and marker beacons are audible.

B (both) All are audible.

R (range) Only Morse code and marker beacons are audible.

VOR/ADF audio source selector
Selects VOR **L**, VOR **R**, ADF **L**, or ADF **R** for monitoring of voice broadcast or Morse code.

Approach audio source selector
Selects ILS **L**, **C**, or **R** for Morse code monitoring, or **MKR** for marker beacon tones.

Receiver selector & volume control (VOR/ADF, APP)

Push (momentary action) Activates or mutes monitoring of selected navaid audio source.

Rotate Adjusts monitor volume.

GREEN LIGHT Monitoring is active.

ACP:

DME Morse codes

A DME station uses 1350 Hz tones, unlike VOR and ILS stations which use 1020 Hz tones. Moreover, a DME tone is louder than VOR and ILS tones, and it only sounds in every fourth transmission cycle; VOR and ILS tones are transmitted in the first three cycles only. These specifications allow the pilot to identify a DME station when it is paired with another station. Lastly, whether or not a certain DME tone is audible depends on the ACP settings, but also on the selected *ND display modes*:

- Morse codes of ILS-paired DME stations are audible on ILS L when the captain's ND is in APP display mode, or are audible on ILS R when the first officer's ND is in APP display mode. ILS C provides no DME monitoring.
- Morse codes of non-ILS-paired DME stations are audible on VOR L when the captain's ND is *not* in APP display mode, or are audible on VOR R when the first officer's ND is *not* in APP display mode.

In all other cases, DME tones cannot be heard; that is, in the fourth transmission cycle, no tone is audible at all.

The ND display modes can be selected on the EFIS control panels and on the left and right CDUs. For more details refer to chapter **Flight Instruments**.

Interphone Speakers:

Captain's interphone speaker, located on left side panel; first officer's interphone speaker is installed on opposite side panel *(interphone speakers are not displayed in the simulator)*.

Volumes are controlled by ACPs. When a PTT switch is pushed, both interphone speakers are muted.

Simulator Specific Factors:

Whether or not the ACP selected sound sources are audible in the simulator depends on the settings on **Instructor > Preferences > Audio** (refer to chapter **Simulator Handling**). For example, the computer can only play sounds on the left interphone speaker if this speaker is activated on the Instructor's Audio page.

Generally, the simulator is able to play a large amount of different sound sources at the same time, but the amount of **Morse code** sources in particular is limited to two, and that of **receiver voice** sources is in most cases limited to one. The simulator applies the following priority logic:

When more than two different **Morse code** sources are selected on the ACPs, and the nav receivers are powered and the stations are in range, the simulator will only play those two Morse code sources that have the highest priority; the priority order, beginning with the highest, is: ILS L, ILS R, ILS C, VOR L, VOR R, ADF L, ADF R. The Morse tones will not overlap; the one station will transmit when the other is pausing between its transmission cycles, and vice versa.—Marker beacon tones can sound anytime; they are not part of the priority logic.

The priority order of the **receiver voice** sources is: CAB, VHL L, VHF R, VHF C, HF L, HF R, VOR L, VOR R. On top of this, ATC has a higher priority than ATIS. For instance, when ATC is on VHF R while ATIS is on VHF L, every ATC message will interrupt the ATIS voice.—Voice broadcast on NDB frequencies (non-aviation related radios) is not modeled. Voices going through the FLT receiver can sound anytime; they are not part of the priority logic.

The priority logic is also linked with the selections on **Instructor > Preferences > Audio.** For example, when VHF L is on the left speaker while VHF R is on the right speaker, and the left speaker is deactivated on the Instructor's Audio page, the simulator will treat VHF L as unselected on the ACP, thus giving VHF R priority over VHF L.

How to start communication with the virtual tug driver in the pushback procedure is described in chapter **Simulator Handling** under **Instructor > Situation > Service**.

PTT switches:

When a crew member's push-to-talk (PTT) switch is pushed and held, the transmitter selected on this crew member's ACP transmits until the switch is released.

PTT switches are installed on the flight deck at several places:

- Captain's glareshield panel
- First officer's glareshield panel
- Captain's yoke
- First officer's yoke
- Captain's hand microphone
- First officer's hand microphone
- Captain's ACP
- First officer's ACP
- Observer's ACP

*(Visualized in the simulator are just the PTT switches on the ACPs and glareshield panels. The captain's and first officer's yoke PTT switches can be assigned to two separate USB buttons on **Instructor** > **Preferences** > **USB**, or to networked hardware. By default, one PTT is also assigned to the H-key on the PC keyboard; if the virtual PNF on **Instructor** > **Situation** > **Human** > **Pilot** is placed on the right-hand seat, the H-key is linked with the captain's system, else with the first officer's system.)*

Captain's PTT switch on left glareshield panel

First officer's PTT switch on right glareshield panel

Overhead Panel:

Captain's audio system switch
(Normally not on all aircraft;
in the simulator installed on all aircraft.)

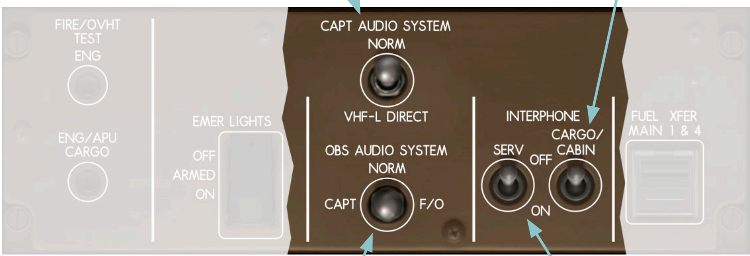
NORM
Normal configuration.

VHF-L DIRECT
Connects captain's microphones, captain's PTT switches, and captain's headset directly with the VHF L radio so that VHF L signals are not routed through the AMU. VHF L is audible in captain's headset only, and the volume is fixed at the maximum. This function may be used in case of stuck microphones or faults in the AMU.

A **Cargo interphone switch**
(Not on passenger aircraft.)

ON Allows communication between cargo interphone and flight interphone.

OFF Isolates cargo and flight interphone systems from each other.



Observer's audio system selector

CAPT Transfers interface of captain's ACP to observer's ACP, so that captain can use observer's ACP when captain's ACP fails.

NORM Normal configuration.

F/O Transfers interface of first officer's ACP to observer's ACP, so that first officer can use observer's ACP when first officer's ACP fails.

(When transferred to the observer's ACP, use the PTT of the observer's ACP, not the PTT of the failed ACP. Normally, this logic is only applied on some aircraft; in the simulator it is applied on all aircraft.)

Service interphone switch

ON Allows communication between service interphone and flight interphone.

OFF Isolates service and flight interphone systems from each other.

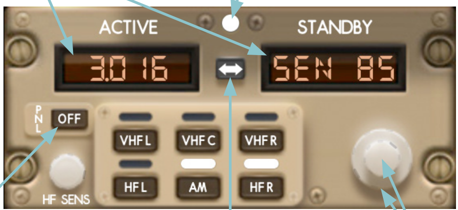
RTP:

Active and standby frequency indicators
Display the active and the preselected standby frequency of the selected radio. The word DATA appears when 137.0 is set on VHF C and ACARS is operational. When the HF SENS selector is rotated while an HF radio is selected, the standby indicator displays SEN and the selected sensitivity for 2 seconds. The indicators are blank when the RTP is off. If a radio is selected that has been locked out by maintenance, each indicator displays INOP. When the RTP fails, PANEL FAIL is displayed across both indicators.

Offside tuning light
Normally, the three RTPs should operate as follows:

- RTP L tunes VHF L and HF L
- RTP R tunes VHF R and HF R
- RTP C tunes VHF C

When an offside radio is selected, the light illuminates on this RTP and on that RTP on which this radio is normally selected. For example, when RTP L selects VHF C, the light illuminates on RTP L and on RTP C. (Light is inoperative on inactive RTPs).



Panel off switch

Push (momentary action) Alternately switches the RTP on and off. For the off-function the switch must be pressed for 2 seconds.

Frequency selectors

Rotate The inner knob selects the two rightmost digits on HF frequencies, and the three rightmost digits on VHF frequencies. The outer knob selects the other digits.

Frequency transfer switch

Push (momentary action) Swaps the standby with the active frequency and tunes the selected radio to the new active frequency. Transfer is inhibited for 1 second after last transfer, or for 3 seconds when DATA has been swapped.

(continued next page)

RTP: *(continued)*

HF sensitivity control

Rotate Sets sensitivity of selected HF receiver. Control is operative also when RTP is switched off.

AM switch

Push (momentary action) Alternately switches between upper side band (USB) and amplitude modulation (AM) for the selected HF radio.

WHITE LIGHT AM is in use.

Radio selection switch (VHF L, C, R; HF L, R)

Push (momentary action) Selects radio for tuning.

WHITE LIGHT Radio is selected.

For Engineers

Lockout feature

Authorized engineers may set certain radio controls inoperative on all RTPs. For example, when the left HF radio is removed from the aircraft, the RTPs may be programmed so that the frequency indicators display INOP when HF L is selected. To program this, depower, for instance, RTP L (pull the VHF L circuit breaker), then, while holding the frequency transfer switch and the HF L radio selection switch on RTP L simultaneously, repower RTP L, then release the switches. The same procedure will remove this feature. *(In the simulator, one mouse can hold just one switch at a time; therefore, the simulator will keep the switches pressed for 5 seconds on an unpowered RTP, allowing the mouse user to click on all required switches.)*

Memory logic

Each RTP stores the active and the standby frequency data for all communication radios, including HF sensitivities and HF modulation methods. Data changed on one RTP is automatically copied to the other RTPs if they are active. When an inactive RTP is reactivated while another RTP is already active, the already active RTP will copy its data to the reactivated RTP. When all RTPs are inactive, the first reactivated RTP will provide the initial dataset. Inactive, in this context, means: the RTP is disconnected by the OFF switch or is depowered entirely.—When RTP control is unavailable, all radios remain operative and tuned to the last set frequency.

Printer:

Self test switch

Push (momentary action) Initiates a test printout.

Paper advance switch

Push (momentary action) Advances the paper as long as the switch is pressed.

Power on light

Illuminates when the printer is powered.

Alert reset switch

Push (momentary action) Resets alerts.

Printer busy light

Illuminates when the printer is busy.

(In the simulator, when the PPR ADV switch is released, or when the printing stops, a virtual crew member will tear the advanced paper off the printer. If the checkbox ***Allow paper sheet simulation*** *is selected on* ***Instructor*** *>* ***Preferences*** *>* ***Basics****, the paper will then float onto the computer's desktop screen for further usage: Blank papers can serve as a notepad, or users may mark the paper text with the mouse and copy it to other desktop applications. In a simulator network, when multiple simulators run on the same computer, no more than one simulator should allow the paper sheet simulation on this computer.)*

Cockpit Voice Recorder:

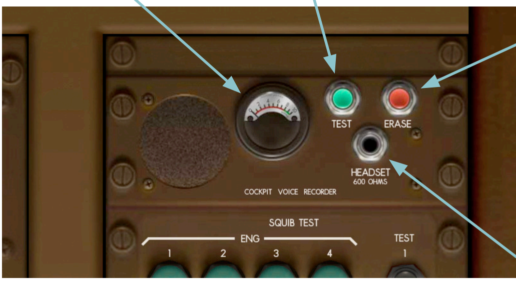
Test procedure

The following four recorder channels are tested: area microphone, captain's audio, first officer's audio, observer's audio. A 600 Hz test tone passes through the first channel for 1 second, then through the next for 1 second, and so on. After the last channel test, it restarts with the first channel. During a successful test, the needle on the monitor stays within the green band. A deviation into the red band indicates a failed channel. The test starts after a delay of 3 seconds, during which the needle indicates zero.
(In the simulator, the voice recorder does not actually record; and the test and erase functions are a simulation only.)

Test switch

Push (momentary action) Test is in progress as long as switch is pressed.

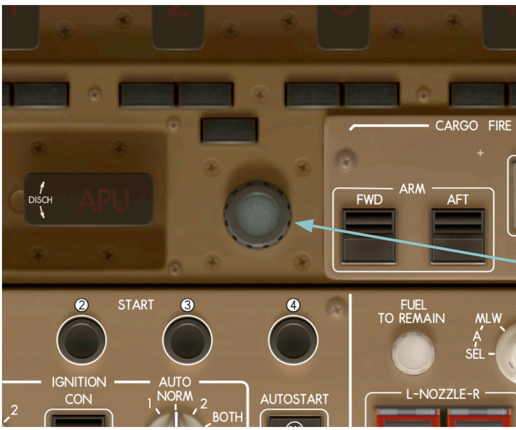
Monitor
Indicates test values.



Erase switch

Push (momentary action) Erases voice recordings when switch is pressed for at least 2 seconds, and aircraft is on ground, and system is powered, and parking brake is set.

Headset jack
May be used to plug in a headset to monitor audio or the test tone *(in the simulator not applicable)*.



Area microphone
Picks up ambient sounds on the flight deck such as conversations and aural alerts. These sounds are routed to one of the voice recorder channels.

A Cabin Interphone System: *(not on freighter)*

Station display
Indicates the station called by the flight deck, or the station calling the flight deck; if multiple stations are calling, also indicates the amount of calls waiting for a reply. When no call is present, displays the installed stations and PA areas when stepping through the directory, otherwise blanks, or displays messages as follows:

- VIDEO IN USE is displayed when a dial key is pushed on the PCP while the passenger video system is in use. The message blanks 5 minutes after the last call or dial activity.
- PA IN USE is displayed when the passenger address system is in use.

The messages are overwritten when a call or directory function is displayed. *(In the simulator, video and PA scenarios can be controlled on* ***Instructor*** *>* ***Situation*** *>* ***Human*** *>* ***Calls****.)*

Priority order of incoming calls

When multiple stations are calling, the list of stored calls is sorted by priority. The station with the highest priority is displayed first. The order is:

1. Pilot alert call
2. All call
3. Priority line call
4. Flight attendant's all call
5. Normal station-to-station call

Reset switch

Push (momentary action) Resets the dialed station code, or terminates the selected call.

Pilots' call panel (PCP)

Brightness sensor
Senses the ambient light intensity and accordingly modulates the brightness of the station display.

Dial key (1, 2, 3, 4, 5, 6, P)

Push (momentary action) Used to dial a two-digit station code. When the second digit is dialed, calls the desired station or PA area. Operative when the CAB transmitter is selected on an ACP, or the handset is off-hook *(in the simulator, the handset is not modeled)*.

Next switch

Push (momentary action) When multiple stations are calling, steps through the list of stored calls. Otherwise, when no call is made, steps through the directory list (the word DIRECTORY indicates the start of the list).

A Cabin Interphone System: *(not on freighter)*

Aural signals

- The *dial signal* is a continuous two-tone sound (350 Hz and 440 Hz); it is audible when the pilots' handset is off-hook or when the CAB transmitter on an ACP is selected, and there is no incoming call.
- The *ring back signal* is a loop of two simultaneous tones (440 Hz and 480 Hz) sounding for 2 seconds and pausing for 4 seconds. It is audible when the handset of the called station is on-hook.
- The *busy signals* are a loop of short tones and short pauses of 0.5 seconds or less. There are two types of busy signals and various conditions triggering them, such as when dialing a station code that does not exist. *(The simulator does not model busy scenarios; it only models the code-does-not-exist condition).*

Operation example:
The captain calls a crew rest station

1. On the captain's ACP push the CAB transmitter selector (one push).
2. Check that the dial signal is audible; adjust the volumes on the ACP if necessary. (Skip 3. if the code is known).
3. On the PCP search for the required station code by stepping through the directory with the NXT key. Stop when CR REST PILOT 66 is displayed. Note the last two digits; they are the station code.
4. Dial the code 66 with the dial keys.
5. If the dialed station is not busy, the ring back signal sounds.
6. When the handset at the called station is off-hook, the ring back signal stops and the conversation can begin.
7. Terminate the conversation by pushing the RST key or by selecting another transmitter on the captain's ACP. *(In the simulator, the virtual person at the called station will never terminate the conversation; it must always be terminated on the flight deck).*

Operation example:
Multiple calls to the flight deck

1. *(On **Instructor** > **Situation** > **Human** > **Calls** push all five buttons under **Cabin**. Each push simulates a call from the cabin to the flight deck. As the interphone system can only store four calls, the Instructor's cabin buttons are disabled when the call buffer is full.)*
2. Check the station display on the PCP. The call with the highest priority is displayed first. The display also indicates W4 which means four calls are waiting.
3. Push the NXT key to step through the list of waiting calls.
4. *(Simplified in the simulator: the model acts as if the station displayed in the call buffer is already dialed; there is no > sign.)*
5. Push the RST key to terminate or cancel the selected call. The call is removed from the call buffer and the display now decreases to W3.
6. Repeat step 5. until the W indication disappears.
7. Terminate the last call with the RST key.

A *Interphone Panel:* *(on freighter)*

Cargo call switch

Push (momentary action)
Activates the flight deck switch lights on the wing inspection station call panels and loadmaster amplifier panels, and a tone on the main cargo deck.

WHITE LIGHT The main cargo deck is calling the flight deck.

Crew rest call switch (left, right)

Push (momentary action)
Activates the respective crew rest area's flight deck switch light and chime.

WHITE LIGHT The respective crew rest area is calling the flight deck.

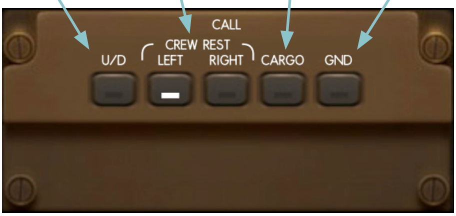
Upper deck call switch

Push (momentary action)
Activates the upper deck's call light and chime.

Ground call switch

Push (momentary action)
Activates the nose wheel well horn for 3 seconds.

WHITE LIGHT The nose wheel station is calling the flight deck.



(In the simulator, calls to the flight deck can be simulated with the buttons on ***Instructor*** *>* ***Situation*** *>* ***Human*** *>* ***Calls****.)*

ACARS – Basics:

The aircraft communications addressing & reporting system (ACARS) provides datalinks for receiving and transmitting digital information between ground stations and the aircraft. Information is transferred via satellite *(not in the simulator)* or via VHF, and is packed into short messages which typically refer to maintenance data, administrative tasks, or flight operations, including CPDLC (for CPDLC refer to chapter **FMS**). For VHF operations, ACARS can use VHF C only: the pilot sets the active VHF C frequency on the RTPs to 137.0; if this is set and ACARS is operational, the RTP indicator displays the word DATA and the ACARS management unit will tune VHF C as required (to frequencies other than 137.0; the 137.0 selection on the RTP is just used as a switch to disable RTP tuning). When not in DATA mode, voice communication is possible, but it will not terminate ACARS operation, and ACARS may, if it fails, interfere with voice communication on VHF C; for this reason, voice communication is not permitted on VHF C. ACARS automatically operates when AC bus 2 or 3 is powered.

The crew can access various ACARS features through one of the three CDUs on the aisle stand. Only one CDU can give access at a time; in normal operations, the center CDU is used. The design of the ACARS pages and features is very much airline specific *(the simulator provides one design sample for all aircraft; it also omits pages that refer to airline specific data such as address data, for instance)*.

ACARS also logs the OOOI times. OOOI stands for: out—off—on—in. That is: *out* of the gate—take*off*—touchdown *on* the runway—*in* the gate. Depending on the current flight phase, ACARS sends reports to the ground station automatically as follows *(partially simplified in the simulator)*:

1. When all doors are closed and the aircraft starts taxiing:
   - Out report
   - Refueling report
2. When the landing gear is decompressed:
   - Off report
3. When the FMC changes from the cruise to the descent phase:
   - ETA report (estimated time of arrival, calculated by the FMC)
4. When the landing gear is compressed:
   - On report
5. When the first door opens:
   - In report

The OOOI times are reset when a new flight number or another airport is entered in the FMC. *(In the simulator, the reports appear on **Instructor** > **Situation** > **Human** > **Dispatcher** on the ACARS telex screen.)*

ACARS – Index Page:

ACARS key
Located on the MENU page of each CDU. Opens the flight phase specific ACARS index page.

Inflight index page

Preflight index page

Postflight index page

ACARS – Flight Plan Data Report Page:

This page can be accessed through line 1L on the ACARS index page; it is only accessible during preflight. The page can be used to report block fuel, taxi fuel, and maximum allowed takeoff weight (MATOW) to the ground station for loadsheet computation *(in the simulator, the report will appear on* ***Instructor*** *>* ***Situation*** *>* ***Human*** *>* ***Dispatcher*** *on the ACARS telex screen)*. The report is sent when the SEND key at line 6R is pushed. The SEND key is available when data is entered on this page.

A Weights are indicated either by kilograms x 1000, or US pounds x 1000, depending on the aircraft model programming.

ACARS – Refueling Report Page:

This page can be accessed through line 2L on the ACARS index page; it is only accessible during preflight. The page can be used to check fuel quantities when refueling is completed. The data are reported automatically when leaving the gate.

*(When refueling is stopped on **Instructor** > **Situation** > **Service**, the simulator will generate a virtual paper sheet that informs about the volume and density of the supplied fuel, provided this feature is enabled on **Instructor** > **Preferences** > **Basics** with the checkbox **Allow paper sheet simulation**. Pilots may enter these values in the respective lines shown below.)*

A Weights are indicated either by kilograms x 1000, or US pounds x 1000, depending on the aircraft model programming.

Displays total fuel weight sensed before refueling started. May be manually overwritten if correction is necessary.

Enter the supplied fuel volume based on the unit in line 2L.

Enter the desired volume unit for 1L using two letters:
LT for liters,
UG for US gallons,
IG for UK gallons.

Displays supplied weight, calculated using entered volume and density.

Enter density of supplied fuel.

On-board weight currently sensed. (Sensor system lags behind actual value by several minutes.)

Enter 2-letter ID of fuel supplier.

Indicates result of: line 2R plus line 3R minus line 4R.

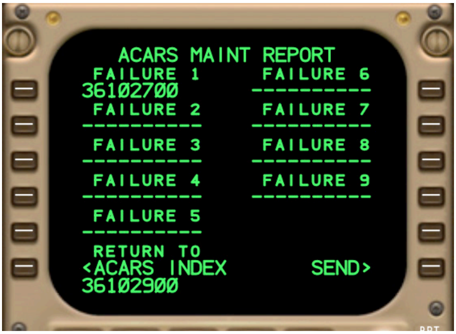
Enter fuel type supplied.

ACARS – OOOI Status Page:

This page can be accessed through line 3L on the ACARS index page. Entries cannot be made on this page. The displayed flight number and the departure and destination airports are forwarded from the active FMC route. Time data are based on the ACARS internal time system when DC power is available from the main hot battery bus; otherwise, if GPS is operative, data are based on GPS time, else on the captain's clock if powered, else on the first officer's clock. The arrow points at the last OOOI event. The page is reset after flight completion when a new flight number or another airport is entered in the FMC.

ACARS – Maintenance Report Page:

This page can be accessed through line 5L on the ACARS index page. Up to 9 failure codes may be entered for a maintenance report. The SEND key is available when an entry is made. *(In the simulator, the report will appear on* ***Instructor*** *>* ***Situation*** *>* ***Human*** *>* ***Dispatcher*** *on the ACARS telex screen.)*



ACARS – Data Frequency Page:

This page can be accessed through line 6L on the ACARS index page. *(In the simulator, the ACARS frequency selection is always in automatic mode with a fixed frequency; manual selection is not possible.)*

ACARS – ATIS Request Page:

This page can be accessed through line 1R on the ACARS index page. Up to 5 airport ICAO codes may be entered in line 1R through line 5R. Line 1L and line 2L can be downselected into the scratchpad. When an entry exists on the right-hand side, the SEND key appears at 6R. When a request is sent, the ground station will process the request and send a list of respective METAR data back to the aircraft. The list will be packed into an ACARS message. ACARS messages received on the aircraft can be accessed through line 6R on the ACARS index page.

*(In the simulator, if the checkbox **Set zones by flight track** is selected on the Instructor's Weather pages, the software will search the latest METAR world database that has been downloaded from the Internet and stored on the hard disk. If the above checkbox is not selected, the software will check if the requested airports are in the Instructor's seven weather zones. In either case, when an airport is found, its associated METAR text—from the world database or from a weather zone—will be added to the list.)*

ACARS – Telex Address Page:

This page can be accessed through line 2R on the ACARS index page. When an address line is selected on this page, another page for free text entries appears with the respective address in the first line.

ACARS – Telex Page:

This is a sample telex page shown when, for example, line 3L has been selected on the above telex address page (TROUBLE SHOOTING). Four lines allow free text entries. The SEND key occurs at 1R when a text is entered. *(In the simulator, the report will appear on* ***Instructor*** *>* ***Situation*** *>* ***Human*** *>* ***Dispatcher*** *on the ACARS telex screen.)*

ACARS – Received Messages Page:

This page can be accessed through line 6R on the ACARS index page. Selecting 1L will display the last received ATIS message; 2L will display the last received free text message. *(The simulator has no message buffer; the latest telex overwrites the previous one. A telex can be written and sent to the aircraft on **Instructor** > **Situation** > **Human** > **Dispatcher**.)*

ACARS – Message Display Page:

The MSG DISPLAY page appears when either ATIS or TELEX has been selected on the above RECEIVED MSGS page. The MSG DISPLAY page displays the text of the received message. If the text is too long to be displayed, the page indicates MSG CAN ONLY BE PRINTED.

ACARS – CDU Scratchpad Messages:

DELETE
The DEL key on the CDU has been pushed. Selecting a line on the CDU screen will delete the entry at this line if the deletion is allowed.

INVALID DELETE
The attempted line deletion is not allowed.

INVALID ENTRY
The attempted line entry has not the required format.

PRINTER FAIL
The printer has been commanded to operate but the printer fails.

PRINTER BUSY
The printer has been commanded to operate but the printer is busy.

ACARS UPLINK
A message from a ground station has been received on the aircraft. The EICAS memo message ACARS MESSAGE appears on the primary EICAS screen. The scratchpad message and the memo message are reset when the pilot selects the ACARS RECEIVED MSGS page on the CDU (accessible through line 6R on the ACARS index page).

The so-called *scratchpad* is the text line at the bottom of the CDU screen. When the system generates a scratchpad message, the MSG light illuminates on the CDU. Pushing the CLR key on the CDU resets the MSG light and the scratchpad message.

(Normally, some more scratchpad messages are provided for various ACARS conditions; in the simulator, the ACARS message system is simplified.)

EICAS Messages:

ADVISORY MESSAGES		
>DATALINK AVAIL		datalink has been lost before and is now available again
>DATALINK LOST		no ACARS communication available causing total datalink loss
>DATALINK SYS		fault in ACARS management unit is causing total datalink loss

MEMO MESSAGES		
ACARS MESSAGE		ACARS datalink message is received and can be viewed on CDU on ACARS RECEIVED MSGS page
VHF DATA OFF		VHF C radio is in voice mode and not tuned by ACARS management unit

Electrical

System Overview:

The electrical system incorporates 115 V AC, 28 V AC, and 28 V DC power sources, and supplies the devices on board with the respective required voltage. In summary:

- **115 V AC** is provided by four engine driven generators, and—during ground operations—by two external generators or two APU generators.
- **28 V AC** is available from transformers powered by 115 V AC.
- **28 V DC** is supplied by batteries, battery chargers, and transformer rectifier units which transform and rectify 115 V AC from the generators to 28 V DC.
- **Standby power** supplies flight critical equipment only and becomes active when the respective primary power source is unavailable, in which case a static inverter will convert the 28 V DC from the battery or battery charger to 115 V AC.
- **Power is distributed** through a configurable network of AC and DC busses. Bus control units, breakers, and relays automatically manage the configuration. The system control also supplies the EICAS with data and alert messages.

(In the simulator, external power can be connected to the aircraft with the checkboxes ***EXT PWR 1*** *and* ***EXT PWR 2*** *on* ***Instructor*** > ***Situation*** > ***Service****. It disconnects automatically when the aircraft starts moving.)*

SYSTEM ANALYSIS

The simulator shows voltage and amperage states of distribution relevant components on **Instructor** > **Analysis** > **Electrical**. The page is intended for use by engineers familiar with the component identifiers.

Bus Tie System:

Every engine contains one **integrated drive generator (IDG)**. In normal operations, IDG power is available when the engine's N2 (or N3) RPM is above 50%. When the engine is flamed out and windmilling, which typically results in an RPM below 50%, IDG power cannot be used.

IDG power is routed through a **generator control breaker (GCB)** to an **AC bus**. There are four AC busses labeled AC bus 1, 2, 3, and 4. Each AC bus powers specific aircraft equipment. The AC busses can be tied with each other through a **synchronous bus**. When they are tied and a GCB opens, the affected equipment remains powered through the other AC busses.

The GCB opens when the power quality of the associated IDG does not meet standard criteria. The IDG is designed to provide 90 kVA through three 115 V, 400 Hz, AC phases, using a constant drive mechanism. IDG parameters are regulated by an associated **generator control unit (GCU)**. The stability of the parameters is particularly important for the synchronous bus system as the AC busses can only be tied together when their IDG outputs are in phase with each other, and their voltages, waveforms, and other parameters agree.

The synchronous bus system incorporates the following breakers and contactors:

- A **split system breaker (SSB)** can split the synchronous bus into two halves so that generators connected to one half are isolated from those connected to the other half.
- Four **bus tie breakers (BTBs)** can connect their respective AC busses with the synchronous bus.
- Two **auxiliary power breakers (APBs)** can connect the **APU generators** to the left or right half of the synchronous bus.
- Two **external power contactors (XPCs)** can connect **external power** sources to the left or right half of the synchronous bus.

In most cases, the performance data of the external and APU generators are identical to those of the IDGs.

(continued next page)

Bus Tie System: *(continued)*

However, only IDGs can be synchronized permanently with each other. Synchronization among external or APU generators is not possible, and they cannot be permanently synchronized with IDGs. When connecting a generator that is not synchronizable with the already connected generators, the **bus control units (BCUs)** command certain bus breakers to open. For this purpose the BCUs apply a programmed schedule for every possible combination of generator connections. BCU 1 normally commands the system components on the left half of the synchronous bus, and BCU 2 those on the right half. Either BCU can open the SSB, but only BCU 2 can close it.

The BCUs accomplish a **no break power transfer (NBPT)** when power is transferred between IDGs, external or APU generators; like, for example, when an APU generator connects while IDGs are already connected, or when an APU generator connects while an external generator is already connected. Only when the generators are precisely synchronized—which may take several seconds—, the system logic will command the respective breaker to close, and the other breaker to open. Power is only interrupted when connecting two APU generators or two external generators while the IDGs are not in use.

In addition to the four AC busses and their tie system, the aircraft also incorporates four **DC busses** and a **DC tie bus**. Each AC bus powers a **transformer rectifier unit (TRU)** whose 28 V DC output is routed to a DC bus. A **DC isolation relay (DCIR)** connects the DC bus to the DC tie bus so that when the DC bus receives no power from its TRU, the other DC busses keep powering the affected DC bus. The controller that commands the BTB of the AC bus also commands the DCIR of the associated DC bus. So when the BTB opens in normal operations, the respective DCIR opens as well.

For **autoland**, the system logic opens the BTBs and DCIRs of busses 1, 2, and 3. Each of these three busses powers a different set of flight systems. When the three busses are isolated from each other, the three sets of flight systems are isolated also. This setting provides a higher safety level as a fault in one system will not propagate to the others.—Should one of the three GCBs open, the respective BTB will close, and IDG 4 will power the affected bus; this will decrease the safety level because, should yet another failure occur, no more backup power will be available. But this degradation will still allow autoland with three independent, operative busses. Only when two or more GCBs open, all BTBs and DCIRs will close, and the autoland function will disengage.

Ground Service Bus:

The ground service bus powers equipment that is used on the ground as well as in flight. The bus is powered automatically when AC bus 1 is powered. When AC bus 1 is unpowered and the aircraft is on the ground, the ground service bus can be reconnected to external power 1 or APU generator 1 when either of them are available. This reconnection, however, can only be controlled manually by pushing the **ground service switch** at door 2L (or 1L). The first push connects, the second push disconnects the bus.

*(In the simulator, the ground service switch is represented on **Instructor** > **Situation** > **Service** under **External supplies**.)*

Ground Handling Bus:

The ground handling bus is powered automatically whenever power is available at the external power 1 receptacle, or when APU generator 1 power is available. External power has priority. The bus cannot be powered in flight; it is just used for ground handling equipment.

A *Cargo Handling Bus:*

The cargo handling bus is installed on freighter and combi aircraft. It is used for main deck cargo equipment. The bus is powered whenever power is available at the external power 2 receptacle, or when APU generator 2 power is available. External power has priority. When the available power is connected to the synchronous bus, that is, when the AVAIL lights of EXT 2 and APU 2 on the overhead panel are extinguished, and an ON light illuminates instead, the cargo handling bus is not powered.

Battery Busses and Hot Battery Busses:

The battery busses are powered by their respective hot battery busses or by DC bus 3 when available. The battery switch on the overhead panel can disconnect the battery busses from the hot battery busses. Battery chargers stabilize the power on the hot battery busses.

Towing Power Bus:

The towing power bus just powers equipment that is essential for towing operations. It is powered by the main battery when the standby power selector on the overhead panel is set to OFF and the towing power switch on the maintenance panel is set to BATTERY.

Utility Busses A *and Galley Busses:*

Every AC bus powers an associated utility bus and—on passenger and combi aircraft—a galley bus. The utility and galley busses supply less important devices that can be disconnected when not enough power is available on the aircraft. The disconnection and reconnection is managed by **electrical load control units (ELCUs)**.

Transfer Busses:

Some of the more important devices are powered through transfer busses which use a backup power source when the primary source fails.

- The **captain's transfer bus** normally uses AC bus 3; and if this fails, AC bus 1.
- The **first officer's transfer bus** normally uses AC bus 2; and if this fails, AC bus 1.

The control system senses the voltage of the respective primary source and will automatically transfer to the backup source when a fault is detected. The control system is powered by DC bus 1; if DC bus 1 is unpowered, the transfer busses will not switch to AC bus 1.

Standby Busses:

The devices that are most important are powered by standby busses. There is a **main standby bus** and an **APU standby bus**. Each standby system can use power from one of three independent sources. Effectively, these are, in the order of their priority:

- AC bus 3
- AC bus 1
- Battery

The power source selection is automatic when the standby power selector on the overhead panel is set to AUTO, which is assumed in the following description:

When the main standby system cannot use AC bus 3, it uses power from the main battery charger; **battery chargers** are powered by AC bus 1 when available via the ground service bus (which, on the ground, may also use external or APU power). If the main battery charger is unusable either, the main standby system uses the main battery.

The APU standby system uses AC bus 3 via the captain's transfer bus which transfers to AC bus 1 on its own when necessary. If the captain's transfer bus provides no power at all, the APU standby system uses the APU battery. At this stage the APU battery charger is already inoperative as the charger requires AC bus 1 power (if the ground service bus is not powered otherwise).—The APU standby bus powers the left FMC and the captain's EFIS instruments. Some aircraft are fitted with an **alternate EFIS selection** system; when the selector is set to F/O, the APU standby system uses the first officer's transfer bus instead of the captain's, and redirects the APU standby power to the first officer's instruments.

Each standby bus system includes a **static inverter** that converts the 28 V DC from the battery or battery charger to 115 V AC. The static inverter of the APU standby system is switched off **during APU start**; this means, when AC bus 1 and 3 are not available, the respective instruments will be inoperative until the APU N2 RPM rises above circa 40%. This takes about 15 seconds.

When the **batteries** are the only power sources in flight, they will provide power for at least 30 minutes. This is approximately the time required to glide from a high cruise altitude down to sea level.

(In the simulator, discharged batteries can be promptly recharged on ***Instructor** > **Situation** > **Service*** *with the button* ***Service batteries**.)*

Main Instrument Panel:

A **Alternate EFIS selector**

CAPT Powers the captain's flight instruments and depowers the first officer's flight instruments when the APU standby bus is powered by the APU hot battery bus.

F/O Powers the first officer's flight instruments and depowers the captain's flight instruments when the APU standby bus is powered by the APU hot battery bus.

A **Standby EFIS selector**

The standby EFIS selector functions in the same way as the alternate EFIS selector.

Overhead Panel:

Standby power selector
The selector must be pushed to rotate it.

OFF Depowers the main standby bus.
Depowers the APU standby bus if *no alternate EFIS selector* is installed or if the alternate transfer busses are unpowered.

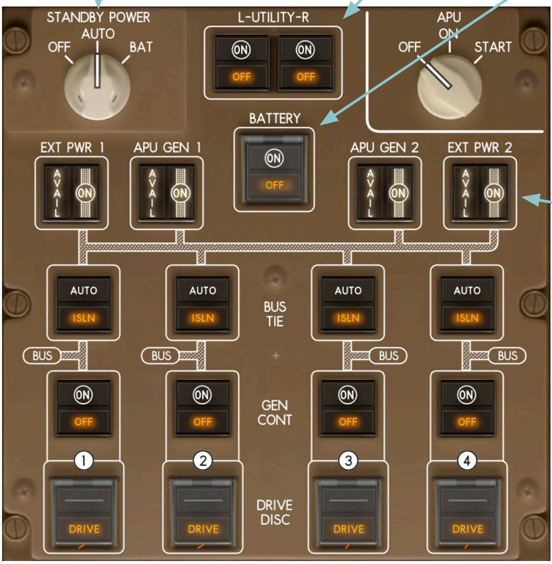
AUTO Enables the main and APU standby bus systems to automatically select the best available power source.

BAT Powers the standby busses and the battery busses by the associated hot battery busses, and disconnects both battery chargers.

Utility switch

ON Powers the respective galley *(not on freighter)* and utility ELCUs (by AC busses 1 and 2 on the left, AC busses 3 and 4 on the right side).

OFF LIGHT An ELCU on the respective side is disconnected due to a fault, or manually switched off.



Battery switch

ON Enables both battery busses to be powered by their hot battery busses when DC bus 3 fails.

OFF LIGHT Battery busses are disconnected from their hot battery busses.

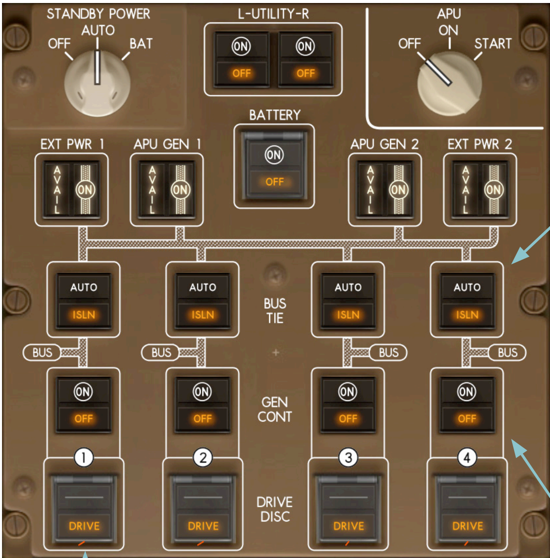
External power and APU generator control switches

Push (momentary action) When power is available, connects the respective power to the synchronous bus (may take several seconds). Second push disconnects the power.

AVAIL LIGHT Power is available, but not connected to the synchronous bus.

ON LIGHT Power is connected to the synchronous bus.

Overhead Panel:



Bus tie switch

AUTO Enables system logic to operate the respective BTB and DCIR.

blank Opens the BTB and DCIR, and resets the fault trip logic.

ISLN LIGHT The BTB is open and the AC bus is isolated from the synchronous bus (automatic isolation during autoland will not illuminate the light).

Generator control switch

ON Closes the respective IDG generator field and enables system logic to operate the GCB.

blank Opens the generator field and GCB, and resets the fault trip logic.

OFF LIGHT The GCB is open and IDG power is removed from the AC bus.

Drive disconnect switch (guarded and wired)
(In the simulator, the guard can be rewired on ***Instructor*** *>* ***Situation*** *>* ***Service*** *with the button* ***Rewire switchguards****.)*

Push (momentary action) Disconnects the IDG's mechanical drive shaft from the engine gearbox. It is only reconnectable by maintenance on the ground *(in the simulator reconnectable on* ***Instructor*** *>* ***Situation*** *>* ***Malfunctions*** *>* ***General*** *under* ***Reset: Malfunctions****)*.

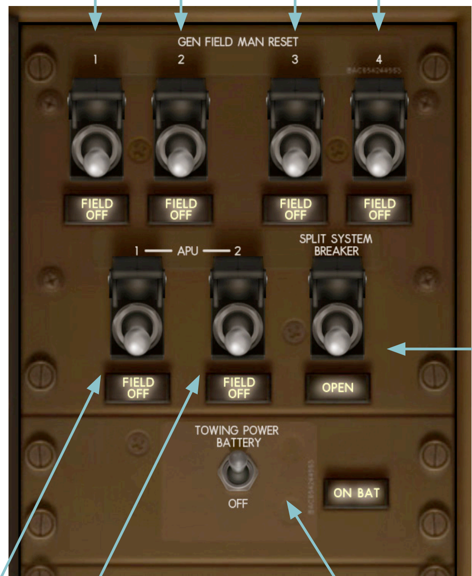
DRIVE LIGHT Oil pressure or oil temperature in drive is not in normal range.

Maintenance Panel:

IDG generator field manual reset switch (guarded)

Push (spring loaded) Alternately opens and closes the generator field of the respective IDG. Opening is accomplished after circa 9 seconds, closing is accomplished with no delay. The switch is only operative when the associated generator control breaker is open and the engine fire switch is not pulled.

FIELD OFF LIGHT IDG generator field is open.



A Toggle switch directions are aircraft specific; the activation functions may be in the upper or in the lower position.

Split system breaker switch (guarded)

Push (spring loaded) Alternately opens and closes the split system breaker if the aircraft is on the ground.

OPEN LIGHT Split system breaker is open.

APU generator field manual reset switch (guarded)

Push (spring loaded) Alternately opens and closes the generator field of the respective APU generator.

FIELD OFF LIGHT APU generator field is open.

Towing power switch

BATTERY Connects the towing power bus to the main battery if the standby power selector is off.

OFF Disconnects the towing power bus.

ON BAT LIGHT Towing power bus is powered by the main battery.

EICAS Electrical Synoptic:

Electrical synoptic switch

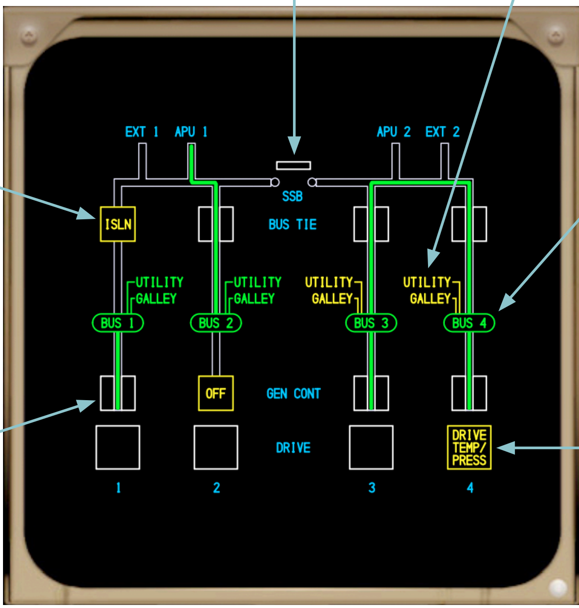
First push Shows electrical synoptic on secondary EICAS display.

Second push Blanks secondary EICAS display.

SSB splits or connects left and right halves of synchronous bus.

Utility and galley busses are green when powered, else amber.

ISLN is indicated when BTB is open.



AC bus is green when powered, else amber.

OFF is indicated when GCB is open.

Amber message indicates drive oil pressure or temperature is not in normal range.

Powerflow bars are green when associated breakers and contactors are closed; they do not indicate whether power is actually flowing.

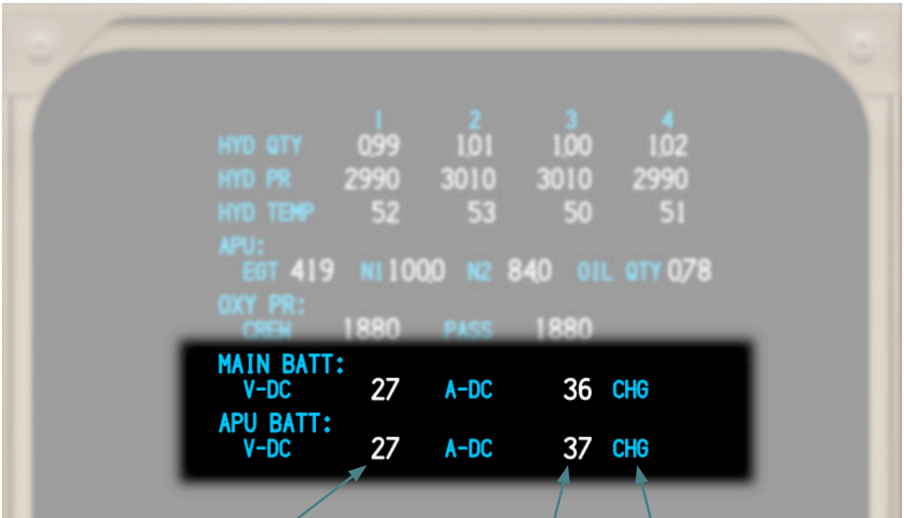
During autoland the electrical synoptic is blank. *(In the simulator, to demonstrate the autoland bus isolation logic, the blanking can be inhibited by setting the HF R standby frequency to 5.555 and the HF R sensitivity to 55.)*

EICAS Status Display:

Status display switch

First push Shows status display with battery indications on secondary EICAS display.

Second push Blanks secondary EICAS display.



Voltages of main and APU batteries.

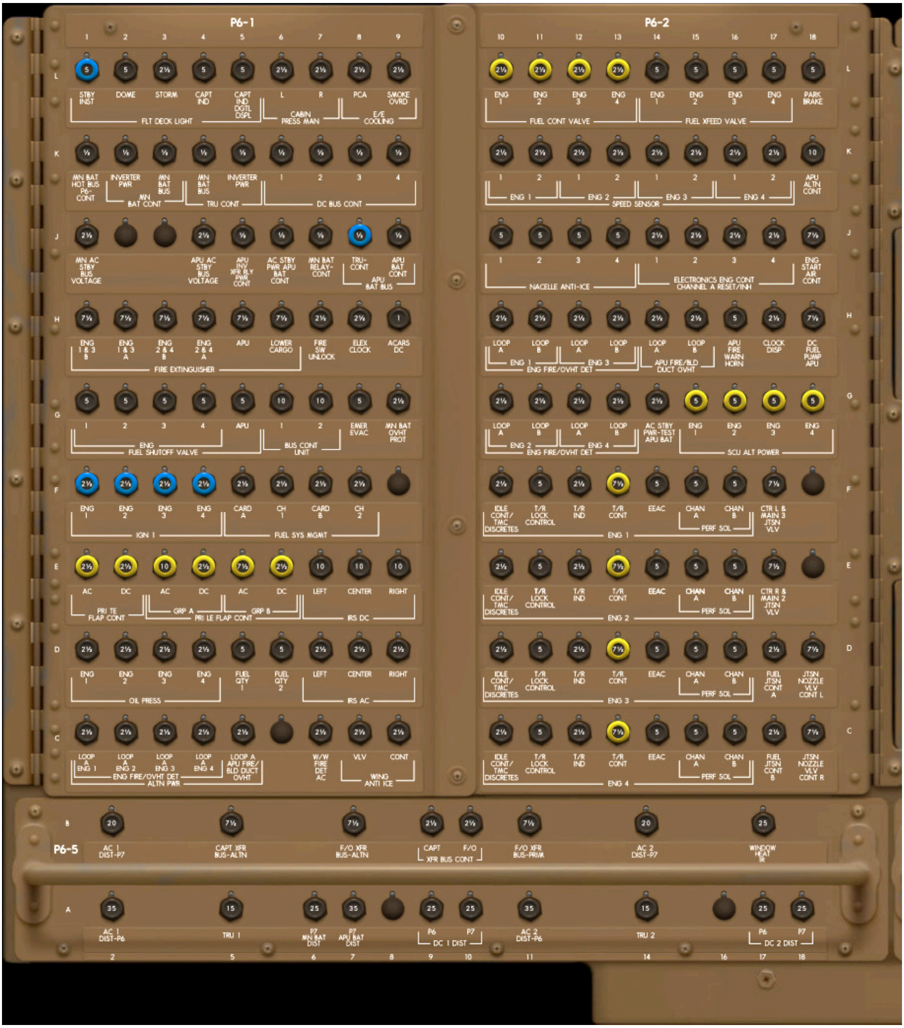
Amperages of main and APU batteries. APU indication is blank during APU start.

Charge status of main and APU batteries.

DIS Discharging
CHG Charging
blank Zero ampere

APU charge status indication is blank during APU start.

Circuit Breaker Panel P6:

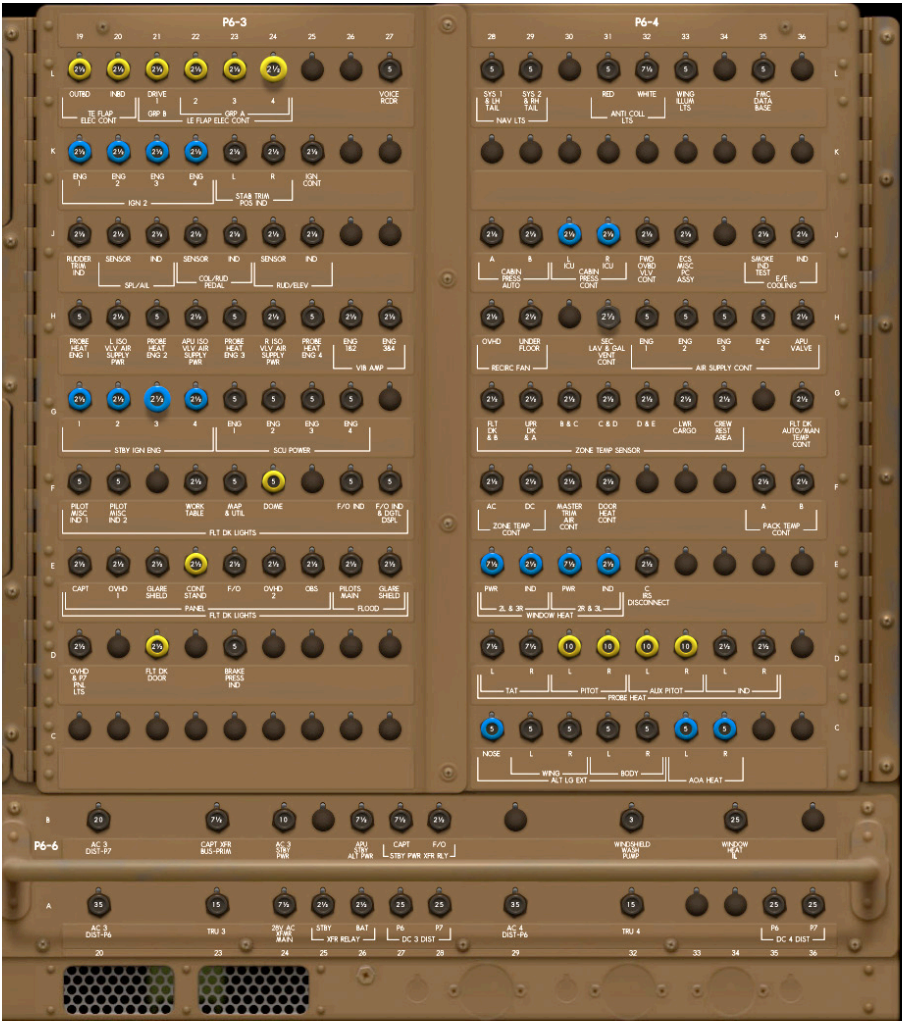


Section 1, 2, and 5 of P6 panel

P6 is located on the lower right-hand side of the flight deck.
The layouts of all CB panels depend on the equipment installed.

(continued next page)

Circuit Breaker Panel P6: *(continued)*

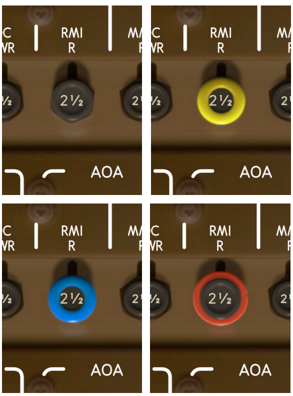


Section 3, 4, and 6 of P6 panel

Circuit Breaker Panel P7:

P7 on overhead panel

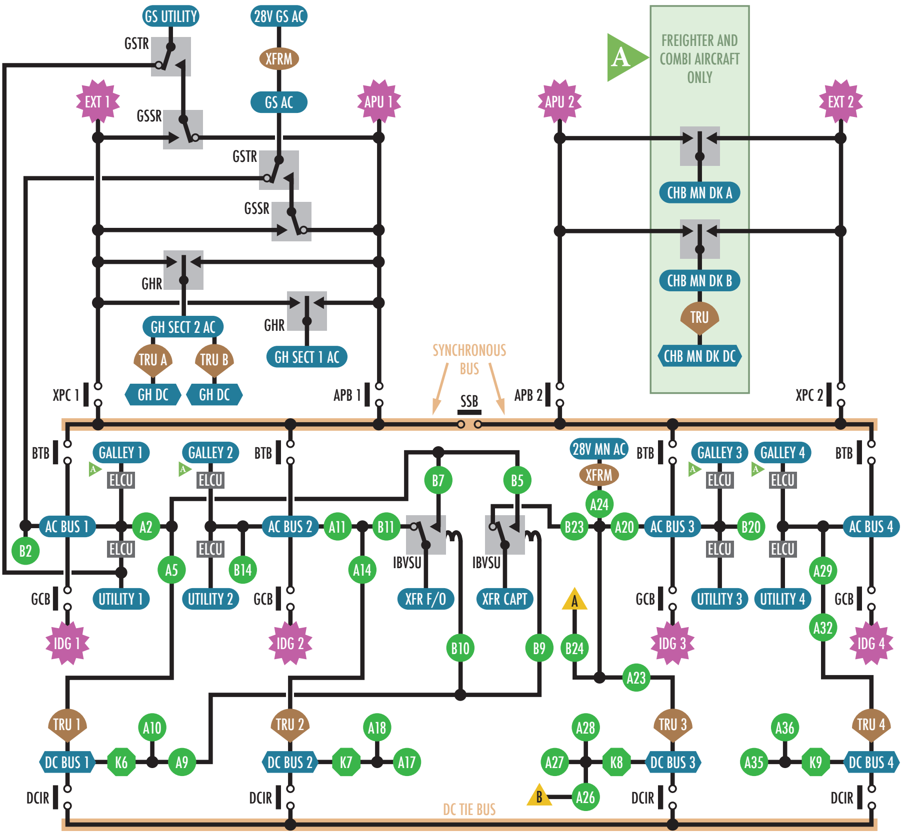
Circuit Breaker Collars and Security Rings:



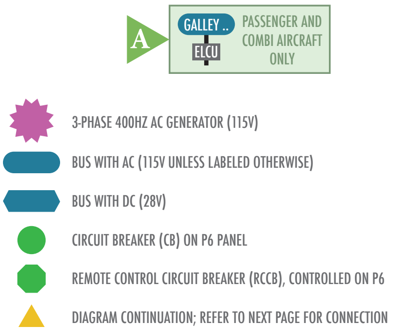
Authorized engineers may mark a CB with a collar in a specific color to indicate a certain maintenance status or task. The meaning of the colors is airline specific; for example, a yellow collar may indicate that the respective CB has to be pulled during short-term maintenance work, while a blue collar may refer to a long-term deactivation. The red ring usually marks an inoperative system and secures the CB in the pulled position.

(The simulator provides yellow and blue collars, and red security rings. To change the color, zoom the panel to factor 0.5 or higher, and click with the mouse on the label above or below the respective CB. Red security rings can only be set on pulled CBs.)

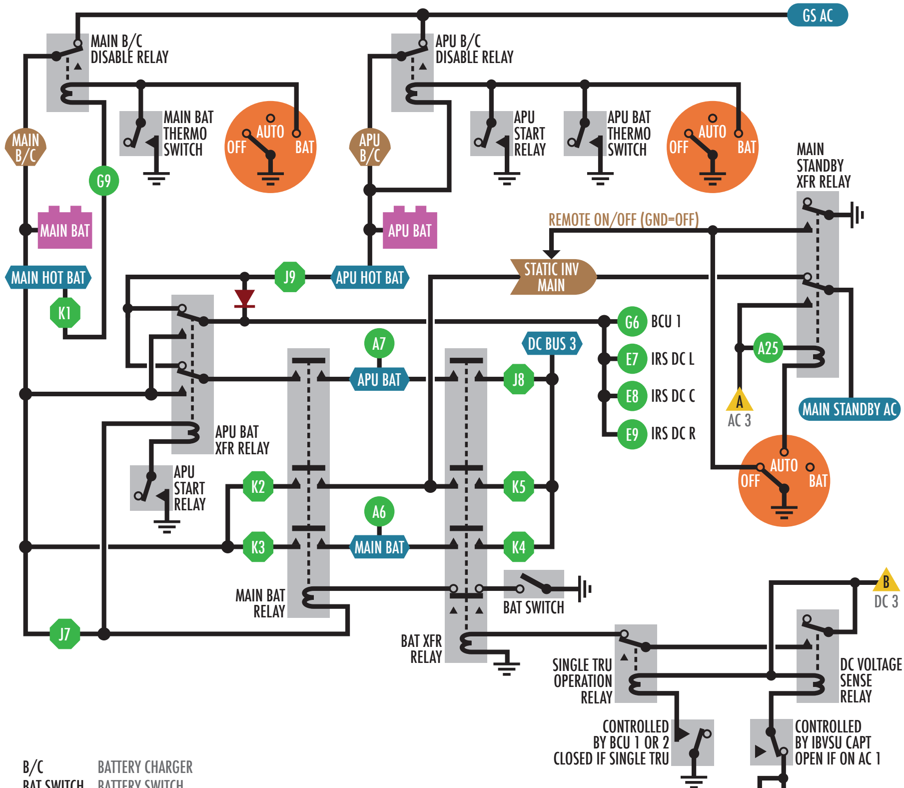
Generator Power Distribution:

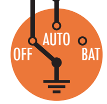


APB	AUXILIARY POWER BREAKER
APU	APU GENERATOR
BTB	BUS TIE BREAKER
CHB MN DK	CARGO HANDLING BUS, MAIN DECK
DCIR	DC ISOLATION RELAY
ELCU	ELECTRICAL LOAD CONTROL UNIT
EXT	EXTERNAL GENERATOR (OF AIRPORT)
GCB	GENERATOR CONTROL BREAKER
GH	GROUND HANDLING
GHR	GROUND HANDLING RELAY
GS	GROUND SERVICE
GSSR	GROUND SERVICE SELECT RELAY
GSTR	GROUND SERVICE TRANSFER RELAY
IDG	INTEGRATED DRIVE GENERATOR
IBVSU	INSTRUMENT BUS VOLTAGE SENSE UNIT
SSB	SPLIT SYSTEM BREAKER
TRU	TRANSFORMER RECTIFIER UNIT
XFR	TRANSFER BUS OF CAPTAIN OR F/O
XFRM	TRANSFORMER (115V AC TO 28V AC)
XPC	EXTERNAL POWER CONTACTOR



Battery Power Distribution:



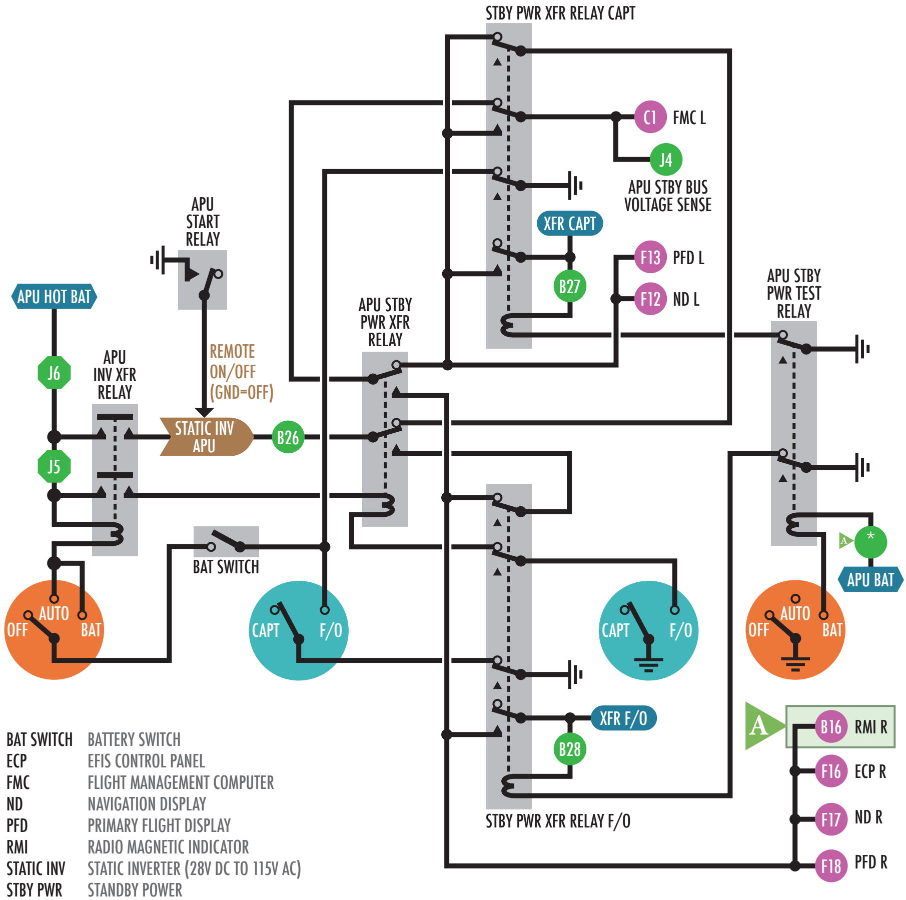


B/C	BATTERY CHARGER
BAT SWITCH	BATTERY SWITCH
BCU	BUS CONTROL UNIT
GS AC	GROUND SERVICE BUS, AC (115V)
IBVSU CAPT	INSTRUMENT BUS VOLTAGE SENSE UNIT OF CAPTAIN
IRS DC	INERTIAL REFERENCE SYSTEM, DC POWER SUPPLY
SINGLE TRU	ONLY ONE TRANSFORMER RECTIFIER UNIT IN USE (REFERRING TO DC BUS 1, 2, 3, 4)
STATIC INV	STATIC INVERTER (28V DC TO 115V AC)
XFR RELAY	TRANSFER RELAY


DIODE
BATTERY (28V)
BUS WITH AC (115V)
BUS WITH DC (28V)
CIRCUIT BREAKER (CB) ON P6 PANEL
REMOTE CONTROL CIRCUIT BREAKER (RCCB), CONTROLLED ON P6
DIAGRAM CONTINUATION; REFER TO PREVIOUS PAGE FOR CONNECTION

SWITCH ELEMENT OF STANDBY POWER SELECTOR

APU Standby Bus System A *with Alternate EFIS Selector:*



BAT SWITCH	BATTERY SWITCH
ECP	EFIS CONTROL PANEL
FMC	FLIGHT MANAGEMENT COMPUTER
ND	NAVIGATION DISPLAY
PFD	PRIMARY FLIGHT DISPLAY
RMI	RADIO MAGNETIC INDICATOR
STATIC INV	STATIC INVERTER (28V DC TO 115V AC)
STBY PWR	STANDBY POWER
XFR CAPT	TRANSFER BUS OF CAPTAIN
XFR F/O	TRANSFER BUS OF FIRST OFFICER
XFR RELAY	TRANSFER RELAY

A * RR: J18
GE & PW: G14

SWITCH ELEMENT OF STANDBY POWER SELECTOR

SWITCH ELEMENT OF ALTERNATE EFIS SELECTOR

BUS WITH AC (115V)

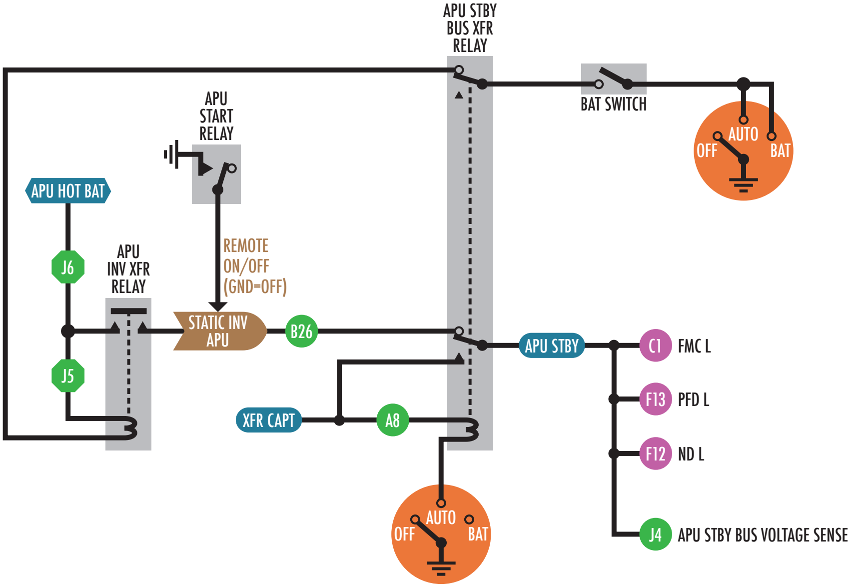
BUS WITH DC (28V)

CIRCUIT BREAKER (CB) ON P7 PANEL

CIRCUIT BREAKER (CB) ON P6 PANEL

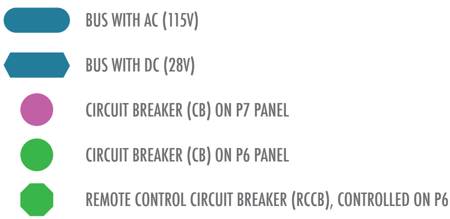
REMOTE CONTROL CIRCUIT BREAKER (RCCB), CONTROLLED ON P6

APU Standby Bus System A *without Alternate EFIS Selector:*



BAT SWITCH	BATTERY SWITCH
FMC	FLIGHT MANAGEMENT COMPUTER
ND	NAVIGATION DISPLAY
PFD	PRIMARY FLIGHT DISPLAY
STBY BUS	STANDBY BUS
STATIC INV	STATIC INVERTER (28V DC TO 115V AC)
XFR CAPT	TRANSFER BUS OF CAPTAIN
XFR RELAY	TRANSFER RELAY

SWITCH ELEMENT OF
STANDBY POWER SELECTOR



AC Bus 1 – Equipment List:

	Distribution CB on P6	Circuit breaker	
	A2	P6 H20	Bleed air isolation valve L
	o/s		Cabin pressurization ICU L – power
	B2	P7 C3	CDU C – electronics
	A2	P6 L27	Cockpit voice recorder
	A2	P6 E3	Flap control – LE group A primary AC
	B2	P7 D13	Flight control computer C – electronics
	B2	P7 C14	Flight controls electronics AC 1R
	o/s		Fuel boost pump FWD 3 (via utility bus L)
A	*o/s*		Fuel scavenge pump *(electric pump)*
	A2	P6 C29	Gear alternate extension – wing L
	A2	P6 C30	Gear alternate extension – wing R
	o/s		Ice detector L
	A2	P6 F1	Ignition 1 – engine 1
	A2	P6 F2	Ignition 1 – engine 2
	A2	P6 F3	Ignition 1 – engine 3
	A2	P6 F4	Ignition 1 – engine 4
	B2	P7 B6	ILS C (MMR C)
	A2	P6 D8	IRU C – AC
	o/s		Landing lights – inboard
A	A2	P6 H19	Probe heat – engine 1 *(PW & RR)*
	A2	P6 C33	Probe heat – AOA L
	A2	P6 D30	Probe heat – pitot captain
	A2	P6 D32	Probe heat – pitot AUX L
	A2	P6 D28	Probe heat – TAT L
	B2	P7 B4	Radio altimeter C
A	*o/s*		Taxi light

o/s : Circuit breaker for this device is located outside the flight deck

AC Bus 2 – Equipment List:

	Distribution CB on P6	Circuit breaker	
	B14	P7 G19	ACARS L – AC
	o/s		APU starter (via utility bus L) *(if not switched to battery)*
	B14	P7 B22	ATC R – electronics
	A11	P6 H22	Bleed air isolation valve APU
	o/s		Cabin pressurization ICU R – power
	B14	P7 B19	DME R
	A11	P6 C7	Fire detection – wheel well
	o/s		Flap control – LE electric drive 1, 4
	B14	P7 D15	Flight control computer R – electronics
	B14	P7 C16	Flight controls electronics AC 2R
	o/s		Fuel boost pump AFT 1
	o/s		Fuel boost pump FWD 4
	o/s		Fuel jettison/override pump CTR L (via utility bus L)
	o/s		Fuel jettison/override pump FWD 2 (via utility bus L)
	o/s		Fuel jettison/override pump FWD 3 (via utility bus L)
	o/s		Fuel transfer pump STAB R
	B14	P7 G23	Gear steering – body AC
	B14	P7 B17	GPS R (MMR R)
A	*o/s*		Hydraulic demand pump 2 *(electric pump)*
	B14	P7 B17	ILS R (MMR R)
	A11	P6 D9	IRU R – AC
A	A11	P6 H21	Probe heat – engine 2 *(PW & RR)*
	B14	P7 C21	Radio altimeter R
	B14	P7 B14	Rudder ratio changer – lower AC (SRM R)
	B14	P7 B21	VOR R
	A11	P6 C8	Wing anti-ice valves
	B14	P7 C19	Weather radar R
	o/s	P6 B17	Window heat power 1R
	A11	P6 E28	Window heat power 2L, 3R
A	A11	P6 G30	Zone temp sensor – B & C *(non-freighter)*
A	A11	P6 G28	Zone temp sensor – flight deck & zone B *(non-freighter)*
A	A11	P6 G30	Zone temp sensor – main deck forward *(freighter)*
	A11	P6 G29	Zone temp sensor – upper deck & zone A

o/s : Circuit breaker for this device is located outside the flight deck

AC Bus 3 – Equipment List:

	Distribution CB on P6	Circuit breaker	
	B20	P7 G20	ACARS R – AC
	B20	P7 B9	ADF L
	A20	P6 H24	Bleed air isolation valve R
	B20	P7 B8	DME L
	B20	P7 D9	EGPWS computer
	o/s		Flap control – LE electric drive 2
	A20	P6 E5	Flap control – LE group B primary AC
	o/s		Flap control – TE electric drive outboard
	B20	P7 D8	Flight control computer L – electronics
	A20	P6 E27	Flood light – glareshield
	A20	P6 E26	Flood light – main instrument panels
	o/s		Fuel boost pump FWD 2 (via utility bus R)
	o/s		Fuel boost pump AFT 3
	o/s		Fuel jettison/override pump CTR R
A	*o/s*		Hydraulic demand pump 3 *(electric pump)*
	o/s		Ice detector R
	A20	P6 K19	Ignition 2 – engine 1
	A20	P6 K20	Ignition 2 – engine 2
	A20	P6 K21	Ignition 2 – engine 3
	A20	P6 K22	Ignition 2 – engine 4
	A20	P6 D7	IRU L – AC
	o/s		Landing lights – outboard
	A20	P6 E23	Panel backlighting – first officer: clock R lightplate, EICAS IDU select R lightplate, EGPWS lightplate, gear lightplate, lighting control R lightplate, A RMI R lighting.

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o/s : Circuit breaker for this device is located outside the flight deck

AC Bus 3 – Equipment List: *(continued)*

	Distribution CB on P6	Circuit breaker	
	A20	P6 E24	Panel backlighting – overhead 2: overhead CVR monitor lighting, overhead EEC lightplate, overhead electrical lightplate & switch shutters, overhead fuel lightplate & switch shutters, overhead hydraulics lightplate, overhead IRS lightplate, overhead light control C lightplate, overhead passenger oxygen & yaw damper lightplate.
	o/s		Printer
A	A20	P6 H23	Probe heat – engine 3 *(PW & RR)*
	B20	P7 B3	Radio altimeter L
	B20	P7 B12	Rudder ratio changer – upper AC (SRM L)
	B20	P7 A5	TCAS
	B20	P7 C7	Weather radar L
	A20	P6 E30	Window heat power 2R, 3L
	A20	P6 F28	Zone temp control – AC
A	A20	P6 G31	Zone temp sensor – C, D *(non-freighter)*
A	A20	P6 G32	Zone temp sensor – D, E *(non-freighter)*
	A20	P6 G33	Zone temp sensor – cargo LWR
A	A20	P6 G34	Zone temp sensor – crew rest area *(non-freighter)*
A	A20	P6 G31	Zone temp sensor – main deck aft *(freighter)*

o/s : Circuit breaker for this device is located outside the flight deck

AC Bus 4 – Equipment List:

Distribution CB on P6	Circuit breaker	
o/s		Flap control – LE electric drive 3
o/s		Flap control – TE electric drive inboard
o/s		Fuel boost pump FWD 1
o/s		Fuel boost pump AFT 4
o/s		Fuel jettison/override pump AFT 2
o/s		Fuel jettison/override pump AFT 3
A29	P6 C28	Gear alternate extension – nose
A29	P6 C31	Gear alternate extension – body L
A29	P6 C32	Gear alternate extension – body R
A29	P6 E19	Panel backlighting – captain: A autobrakes lightplate *(if installed under ND)*, clock L lightplate *, EICAS IDU select L lightplate, FMS source select lightplate, hydraulic brake pressure lighting *(if towing power off)*, A ISFD lightplate *, lighting control L lightplate, A RMI L lighting *, source select L lightplate, A standby attitude/airspeed/altimeter lighting *.
A29	P6 D19	Panel backlighting – overhead & P7: overhead air conditioning switch shutters, overhead anti-ice switch shutters **, overhead autostart switch shutter, overhead circuit breaker lightplates, overhead EEC switch shutters, overhead fire arm switch shutters, overhead hydraulic switch shutters, overhead jettison switch shutters, overhead ignition switch shutter **, overhead fuel XFR main 1 & 4 switch shutter, overhead yaw damper switch shutters,

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o/s : Circuit breaker for this device is located outside the flight deck
** Can also be powered by main standby bus (P6 L1)*
*** Can also be powered by main standby bus (P6 L1) if no power on P6 E19 and E20*

AC Bus 4 – Equipment List: *(continued)*

Distribution CB on P6	Circuit breaker	
A29	P6 E20	Panel backlighting – overhead 1: overhead air conditioning lightplate, overhead bleed air lightplate and switch shutters, overhead cabin altitude lightplate, overhead ELT lightplate, overhead fire lightplate, overhead ice and rain protection lightplate, overhead ignition and jettison lightplate, overhead light control L & R lightplates, overhead window heat switch shutters *.
A29	P6 E21	Panel backlighting – glareshield: glareshield lightplates *, standby compass lighting *.
A29	P6 E22	Panel backlighting – aisle stand: ATC lightplate *, ACP lightplates *, A autobrakes lightplate *(if installed on aisle stand)*, call lightplate, CDU L lightplate *, CDU R & C lightplates, evacuation lightplate, passenger signs lightplate, printer lightplate, RTP L lightplate *, RTP R & C lightplates, rudder trim lightplate, stab trim lightplates, thrust control lightplate, weather radar lightplate.
A A29	P6 H25	Probe heat – engine 4 *(PW & RR)*
A29	P6 C34	Probe heat – AOA R
A29	P6 D31	Probe heat – pitot F/O
A29	P6 D33	Probe heat – pitot AUX R
A29	P6 D29	Probe heat – TAT R
A29	P6 H26	Vibration monitor – engine 1 & 2
A29	P6 H27	Vibration monitor – engine 3 & 4
o/s	P6 B34	Window heat power 1L
A29	P6 B32	Windshield washer pump

o/s : Circuit breaker for this device is located outside the flight deck
** Can also be powered by main standby bus (P6 L1)*

DC Bus 1 – Equipment List:

Distribution CB on P6	Circuit breaker	
A10	P7 A22	ACP C – electronics
o/s		Antiskid card 14-16
A9	P6 H32	ASCTU – engine 1
A10	P7 A4	Aural warning speaker R
A10	P7 C4	Autothrottle L – servo
o/s		Brake temperature monitor
o/s		Brake torque limiter card 1-5 & 9-13
A9	P6 J28	Cabin pressurization – auto control A
A9	P6 J30	Cabin pressurization – ICU L control
o/s		EEC channel A & B power – engine 1
A9	P6 C1	Fire/overheat detector loop A alternate – engine 1
A9	P6 E4	Flap control – LE group A primary DC
A9	P6 L21	Flap electric drive 1 LE – control
A10	P7 D12	Flight control computer C – servo
o/s		Flight control shutoff valves – wing 1 & tail 1
A10	P7 C15	Flight controls electronics DC 1R
A10	P7 C5	FMS master switch relay
A *o/s*		Fuel control – auxiliary tank system
o/s		Fuel control – boost pumps AFT 2 & FWD 3
A9	P6 F17	Fuel jettison valve – center L & main 3
A9	P6 F5	Fuel system management – card A
A9	P6 F6	Fuel system management – channel 1
A10	P7 H21	Fuel transfer valve – main tank 1
A10	P7 H22	Fuel transfer valve – reserve tanks 2A & 3A
A A10	P7 H25	Fuel transfer valve – stabilizer tank L
A10	P7 H8	Ground safety relay
A10	P7 J3	HYDIM 4 *(if not powered by ground handling bus)*
A10	P7 J1	Hydraulic demand pump 1 – control
A10	P7 J2	Hydraulic EDP depress 1 – control

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o/s : *Circuit breaker for this device is located outside the flight deck*

DC Bus 1 – Equipment List: *(continued)*

	Distribution CB on P6	Circuit breaker	
	A9	P6 F10	Idle control/TMC discretes – engine 1
	A9	P6 K25	Ignition control – all engines
	A10	P7 D23	ILS C – antenna switch
	A9	P6 F26	Indicators F/O and other MD&T lights (& dim test delay)
	A9	P6 F27	Indicators & displays F/O and other MD&T lights
	A9	P6 J10	Nacelle anti-ice – engine 1
	A9	P6 D34	Probe heat control/indication L
	A10	P7 F21	RTP R – electronics
A	A9	P6 G23	SCU power – engine 1 *(PW)*
	A10	P7 H14	Smoke detector loops A – lower cargo
	A9	P6 F13	Thrust reverser control – engine 1
	A9	P6 C13	Thrust reverser control – engine 4
	A9	P6 F12	Thrust reverser indication – engine 1
	A9	P6 C12	Thrust reverser indication – engine 4
A	A9	P6 F11	Thrust reverser interlock – engine 1 *(GE & PW)*
A	A9	P6 C11	Thrust reverser interlock – engine 4 *(GE & PW)*
	A10	P7 F21	VHF R

DC Bus 2 – Equipment List:

	Distribution CB on P6	Circuit breaker	
A	A18	P7 J17	ADC C pitot/static XFR valve *(if third ADC installed)*
A	A18	P7 J20	ADC source select – F/O *(if third ADC installed)*
	A18	P7 D18	Aileron lockout control
A	A17	P6 E34	Air conditioning control – cargo PCA *(freighter)*
	o/s		Antiskid card 13-15
	A17	P6 H33	ASCTU – engine 2
	A18	P7 C26	Autothrottle R – servo
	o/s		Brake torque limiter card 2-6 & 10-14
	A17	P6 J29	Cabin pressurization – auto control B
	A17	P6 J32	Cabin pressurization – forward overboard valve control
	A17	P6 J31	Cabin pressurization – ICU R control
	A17	P6 J33	ECS miscellaneous card
	o/s		EEC channel A & B power – engine 2
	A17	P6 C5	Fire/overheat detector loop A alternate – APU
	A17	P6 C2	Fire/overheat detector loop A alternate – engine 2
A	A18	P7 F6	Fire main deck cargo – A/C SOV control *(freighter)*
	A18	P7 D14	Flight control computer R – servo
	o/s		Flight control shutoff valves – wing 2 & tail 2
	A18	P7 C17	Flight controls electronics DC 2R
	o/s		Fuel control – boost pumps AFT 1 & FWD 4
	o/s		Fuel control – override/jettison pump CTR L
	o/s		Fuel control – override/jettison pumps FWD 2 & 3
	A17	P6 E17	Fuel jettison valve CTR R & main 2
	A17	P6 F7	Fuel system management card B
	A17	P6 F8	Fuel system management channel 2
	A18	P7 H24	Fuel transfer valve – main tank 4
	A18	P7 H23	Fuel transfer valve – reserve tanks 2B & 3B
A	A18	P7 H26	Fuel transfer valve – stabilizer tank R
	A18	P7 F23	Gear display & control – alternate
	A18	P7 F24	Gear lever lock
	A18	P7 G24	Gear steering – body DC
	A18	P7 G25	Gear steering – nose primary

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o/s : Circuit breaker for this device is located outside the flight deck

DC Bus 2 – Equipment List: *(continued)*

	Distribution CB on P6	Circuit breaker	
	A18	P7 H3	HYDIM 3
	A18	P7 H1	Hydraulic demand pump 2 – control
	A18	P7 H2	Hydraulic EDP depress 2 – control
	A17	P6 E10	Idle control/TMC discretes – engine 2
	A18	P7 D24	ILS R – antenna switch
	A18	P7 E18	MCP R – electronics
	A17	P6 J11	Nacelle anti-ice – engine 2
	A18	P7 F26	PSEU section 2
	A18	P7 B15	Rudder ratio changer – lower DC (SRM R)
	A17	P6 G24	SCU power – engine 2 (PW)
A	A18	P7 H16	Smoke detector loop A – MN DK ZN 1-8 *(non-pax)*
A	A18	P7 H18	Smoke detector loop A – MN DK ZN 9-16 *(non-pax)*
	A18	P7 H15	Smoke detector loop B – lower cargo
	A18	P7 E19	Stabilizer trim R – control
	A18	P7 E21	Stabilizer trim R – rate
	A18	P7 E20	Stabilizer trim R – SOV
	A18	P7 D19	Stick shaker R
	A17	P6 E13	Thrust reverser control – engine 2
	A17	P6 D13	Thrust reverser control – engine 3
	A17	P6 E12	Thrust reverser indication – engine 2
	A17	P6 D12	Thrust reverser indication – engine 3
A	A17	P6 E11	Thrust reverser interlock – engine 2 *(GE & PW)*
A	A17	P6 D11	Thrust reverser interlock – engine 3 *(GE & PW)*
	A18	P7 B23	Transponder antenna
A	A17	P6 H31	Vent fans lavatory & galley *(non-freighter)*
	A17	P6 C9	Wing anti-ice control
	A18	P7 C18	Yaw damper – lower
	A17	P6 E29	Window heat control 2L, 3R

DC Bus 3 – Equipment List:

	Distribution CB on P6	Circuit breaker	
A	A28	P7 J19	ADC source select – captain *(if third ADC installed)*
	A28	P7 D17	Aileron trim
	o/s		Antiskid card 10-12
	A27	P6 H34	ASCTU – engine 3
	o/s		Autobrakes control
	o/s		Brake torque limiter card 3-7 & 11-15
	o/s		Cabin pressurization – forward overboard valve power
	A27	P6 F29	Cabin temperature control – DC
	A27	P6 G36	Cabin temperature control – flight deck auto/manual
A	A27	P6 F31	Cabin temperature control – heat crew rest *(freighter)*
A	A27	P6 F31	Cabin temperature control – heat door *(non-freighter)*
	A27	P6 F30	Cabin temperature control – master trim air
	o/s		EEC channel A & B power – engine 3
	A27	P6 C3	Fire/overheat detector loop A alternate – engine 3
	A27	P6 E6	Flap control – LE group B primary DC
	A27	P6 L22	Flap electric drive 2 LE – control
	A27	P6 L23	Flap electric drive 3 LE – control
	A27	P6 L24	Flap electric drive 4 LE – control
	A27	P6 L20	Flap electric drive inboard TE – control
	A28	P7 D7	Flight control computer L – servo
	A27	P6 J25	Flight control indication – rudder & elevator
	o/s		Flight control shutoff valves – wing 3 & tail 3
	o/s		Fuel control – boost pumps AFT 3 & FWD 2
	o/s		Fuel control – override/jettison pump CTR R
	A27	P6 D17	Fuel jettison – control A
	A27	P6 D18	Fuel jettison – nozzle valve L
	A27	P6 D5	Fuel quantity indication 1
	o/s		Fuel system EICAS interface
	A28	P7 G26	Gear steering – nose alternate

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o/s : Circuit breaker for this device is located outside the flight deck

DC Bus 3 – Equipment List: *(continued)*

	Distribution CB on P6	Circuit breaker	
	A28	P7 G3	HYDIM 2
	A28	P7 G1	Hydraulic demand pump 3 – control
	A28	P7 G2	Hydraulic EDP depress 3 – control
	A28	P7 G4	Hydraulic fluid quantity indication 1, 2, 3, 4
	A27	P6 D10	Idle control/TMC discretes – engine 3
	A27	P6 F19	Indicator lights pilot's MISC 1 and other MD&T lights
	A27	P6 F20	Indicator lights pilot's MISC 2 and other MD&T lights
	A27	P6 E32	IRU C – disconnect relay
	A28	P7 E9	MCP L – electronics
	A27	P6 J12	Nacelle anti-ice – engine 3
	A27	P6 F35	Pack temperature controller A
A	A27	P6 H28	Recirculation fans – upper *(non-freighter)*
	A28	P7 F20	RTP C – electronics
	A27	P6 J25	Rudder & elevator indication
	A28	P7 B13	Rudder ratio changer – upper DC (SRM L)
	A28	P7 D16	Rudder trim control
A	A27	P6 G25	SCU power – engine 3 *(PW)*
	A28	P7 G6	Speedbrake auto control
	A28	P7 E6	Stabilizer trim L – control
	A28	P7 E8	Stabilizer trim L – rate
	A28	P7 E7	Stabilizer trim L – SOV
	A28	P7 D6	Terrain display relay
	A28	P7 F20	VHF C
	A27	P6 E31	Window heat control 2R, 3L
	A28	P7 E1	Windshield wiper L

DC Bus 4 – Equipment List:

	Distribution CB on P6	Circuit breaker	
	o/s		Antiskid card 9-11
	A35	P6 H36	APU air supply control
	A35	P6 H35	ASCTU – engine 4
	o/s		Brake torque limiter card 4-8 & 12-16
	A36	P7 A19	Call panel electronics – dual alternate
	o/s		EEC channel A & B power – engine 4
	A36	P7 G14	Emergency lights battery charge – forward
	A36	P7 G15	Emergency lights battery charge – aft
	A35	P6 C4	Fire/overheat detector loop A alternate – engine 4
	A35	P6 L19	Flap electric drive outboard TE – control
	o/s		Flight control shutoff valves – wing 4 & tail 4
	o/s		Fuel control – boost pumps AFT 4 & FWD 1
	o/s		Fuel control – override/jettison pumps AFT 2 & 3
	A35	P6 C17	Fuel jettison – control B
	A35	P6 C18	Fuel jettison – nozzle valve R
	A35	P6 D6	Fuel quantity indication 2
	A35	P6 C10	Idle control/TMC discretes – engine 4
	A36	P7 F1	Hydraulic demand pump 4 – control
	A36	P7 F2	Hydraulic EDP depress 4 – control
	A36	P7 F3	HYDIM 1 *
	A35	P6 J13	Nacelle anti-ice – engine 4
	A35	P6 F36	Pack temperature controller B
	A35	P6 D35	Probe heat control/indication R
	o/s		PSEU ground test
A	A35	P6 H29	Recirculation fans – lower *(non-freighter)*
A	A35	P6 G26	SCU power – engine 4 *(PW)*
A	A36	P7 H17	Smoke detector loop B – MN DK ZN 1-8 *(non-pax)*
A	A36	P7 H19	Smoke detector loop B – MN DK ZN 9-16 *(non-pax)*
	A36	P7 G7	Speedbrake flight detent lever lock
	A35	P6 J21	Flight control indication – spoiler & aileron
A	*o/s*		Tire pressure monitor *(if not on ground handling bus)*
	A36	P7 E26	Windshield washer nozzles
	A36	P7 E25	Windshield wiper R

o/s : Circuit breaker for this device is located outside the flight deck

** Primarily powered by ground handling bus if AUX 1 pump installed*

Transfer Bus Captain – Equipment List:

	Distribution CB on P6	Circuit breaker	
A	*direct*	P7 J15	ADC C
	direct	P7 A17	AOA sensor R2
	direct	P7 F10	EIU C
	direct	P7 E12	HF L
	direct	P7 B1	MAWEA power B
	direct	P7 D11	PVD

Transfer Bus First Officer – Equipment List:

	Distribution CB on P6	Circuit breaker	
	direct	P7 A14	ADC R
	direct	P7 A16	AOA sensor R1
	direct	P7 C25	Autothrottle excitation
	direct	P7 C24	CDU R – electronics
A	*direct*	P7 F16	EFIS control R – electronics *
	direct	P7 F15	EIU R
	direct	P7 C23	FMC R
	direct	P7 E15	HF R
	direct	P7 F14	EICAS display – lower
A	*direct*	P7 F18	PFD R *
A	*direct*	P7 F17	ND R *
A	*direct*	P7 B16	RMI R – electronics *

* *If alternate EFIS selector is not installed*

APU Battery Bus – Equipment List:

	Distribution CB on P6	Circuit breaker	
	A7	P7 A21	ACP R – electronics
	direct	*direct*	BCU 2 *(if not powered otherwise)*
A	A7	P7 A25	Call – cabin *(non-freighter)*
A	A7	P7 A24	Call – cargo *(freighter)*
A	A7	P7 A26	Call – crew rest *(freighter)*
A	A7	P7 A25	Call – ground crew *(freighter)*
	A7	P7 A23	Call – service interphone
	A7	P7 A18	Call panel – dual main
	direct	P6 H17	Clocks – digital displays
	direct	P6 H16	Fire warning horn – APU
	direct	P6 H14	Fire/overheat detector loop A – APU
	direct	P6 H10	Fire/overheat detector loop A – engine 1
	direct	P6 G10	Fire/overheat detector loop A – engine 2
	direct	P6 H12	Fire/overheat detector loop A – engine 3
	direct	P6 G12	Fire/overheat detector loop A – engine 4
	direct	P6 H15	Fire/overheat detector loop B – APU
	direct	P6 H11	Fire/overheat detector loop B – engine 1
	direct	P6 G11	Fire/overheat detector loop B – engine 2
	direct	P6 H13	Fire/overheat detector loop B – engine 3
	direct	P6 G13	Fire/overheat detector loop B – engine 4
	direct	P6 H18	Fuel pump DC APU
	A7	P7 F22	Gear display & control – primary
	direct	P6 L5	Indicators & displays captain and other MD&T lights
	A7	P7 J9	Passenger address – system 1
A	A7	P7 J10	Passenger address – system 2 *(non-freighter)*
A	A7	P7 J11	Passenger address – system 3 *(non-freighter)*
A	A7	P7 J12	Passenger address – system 4 *(non-freighter)*
	A7	P7 F25	PSEU section 1

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APU Battery Bus – Equipment List: *(continued)*

	Distribution CB on P6	Circuit breaker	
	direct	P6 K10	Speed card 1 – engine 1
	direct	P6 K12	Speed card 1 – engine 2
	direct	P6 K14	Speed card 1 – engine 3
	direct	P6 K16	Speed card 1 – engine 4
	direct	P6 K11	Speed card 2 – engine 1
	direct	P6 K13	Speed card 2 – engine 2
	direct	P6 K15	Speed card 2 – engine 3
	direct	P6 K17	Speed card 2 – engine 4
A	*direct*	P6 J18	Start air control – all engines *(GE & PW)*
A	*direct*	P6 G14	Start/ignition control – engine 1 *(RR)*
A	*direct*	P6 G15	Start/ignition control – engine 2 *(RR)*
A	*direct*	P6 G16	Start/ignition control – engine 3 *(RR)*
A	*direct*	P6 G17	Start/ignition control – engine 4 *(RR)*

APU Hot Battery Bus – Equipment List:

Distribution CB on P6	Circuit breaker	
direct	*direct*	APU control – primary
J9	P6 G6	BCU 1 *(if not powered otherwise)*
J9	P6 E8	IRU C – DC *(not during APU start)*
J9	P6 E7	IRU L – DC *(not during APU start)*
J9	P6 E9	IRU R – DC *(not during APU start)*
direct	*direct*	Outflow valve L – power
direct	*direct*	Outflow valve R – power

APU Standby Bus A with Alternate EFIS Selector – Equipment List:

	Distribution CB on P6	Circuit breaker	
	direct	P6 J4	APU standby bus – voltage sensor
	direct	P7 F16	EFIS control panel R – electronics *
	direct	P7 C1	FMC L
	direct	P7 F12	ND L **
	direct	P7 F17	ND R *
	direct	P7 F13	PFD L **
	direct	P7 F18	PFD R *
A	*direct*	P7 B16	RMI R – electronics *

* *If alternate EFIS selector is in F/O position*

** *If alternate EFIS selector is in CAPT position*

APU Standby Bus A without Alternate EFIS Selector – Equipment List:

Distribution CB on P6	Circuit breaker	
direct	P7 C1	FMC L
direct	P7 F12	ND L
direct	P7 F13	PFD L

Main Battery Bus – Equipment List:

Distribution CB on P6	Circuit breaker	
A6	P7 A20	ACP L – electronics
direct	P6 K18	APU control – alternate
A6	P7 A3	Aural warning speaker L
A6	P7 E24	Autoflight warning
direct	*direct*	BCU 1 *(if not powered otherwise)*
direct	P6 L6	Cabin press MAN control L *(if auto control A unpowered)*
direct	P6 L7	Cabin press MAN control R *(if auto control B unpowered)*
direct	P6 L2	Dome lights **
direct	P6 L8	Equipment cooling – PCA
direct	P6 L9	Equipment cooling – smoke override
direct	P6 E2	Flap control – TE primary DC
A6	P7 C13	Flight controls electronics DC 1L
A6	P7 C11	Flight controls electronics DC 2L
direct	P6 L2	Flood light – aisle *
direct	P6 L10	Fuel control valve – engine 1
direct	P6 L11	Fuel control valve – engine 2
direct	P6 L12	Fuel control valve – engine 3
direct	P6 L13	Fuel control valve – engine 4
direct	P6 L14	Fuel crossfeed valve – engine 1
direct	P6 L15	Fuel crossfeed valve – engine 2
direct	P6 L16	Fuel crossfeed valve – engine 3
direct	P6 L17	Fuel crossfeed valve – engine 4
A6	P7 J4	Hydraulic EDP 1 – supply
A6	P7 J5	Hydraulic EDP 2 – supply
A6	P7 J6	Hydraulic EDP 3 – supply
A6	P7 J7	Hydraulic EDP 4 – supply

(continued next page)

* *Dimmer fixed at 12 V if ground service bus 28 V AC is off or if P6 F24 is pulled*

** *On this bus and dimmer fixed at 12 V if ground service bus 28 V AC is off or if P6 F24 is pulled*

Main Battery Bus – Equipment List: *(continued)*

	Distribution CB on P6	Circuit breaker	
	direct	*direct*	IDG disconnect – all engines
	A6	P7 D22	ILS L – antenna switch
	direct	P6 L4	Indicator lights captain and other MD&T lights
A	A6	P7 B25	ISFD battery charger
	A6	P7 D3	Oxygen reset
	A6	P7 D4	Oxygen valve and indication
	direct	P6 L18	Parking brake control *(if not on towing power bus)*
	A6	P7 F19	RTP L – electronics
A	*direct*	P6 G15	SCU power alternate – engine 1 *(PW)*
A	*direct*	P6 G16	SCU power alternate – engine 2 *(PW)*
A	*direct*	P6 G17	SCU power alternate – engine 3 *(PW)*
A	*direct*	P6 G18	SCU power alternate – engine 4 *(PW)*
	A6	P7 E23	Stab trim – alternate control
A	A6	P7 B26	Standby altimeter vibrator
A	A6	P7 B25	Standby attitude gyro
A	A6	P7 B24	Standby ILS indicator
	A6	P7 D5	Stick shaker L
	direct	P6 L3	Storm light
	A6	P7 F19	VHF L
	A6	P7 C9	Yaw damper – upper

Main Hot Battery Bus – Equipment List:

	Distribution CB on P6	Circuit breaker	
	K1	P6 H9	ACARS – DC
	K1	P6 G7	BCU 2 *(if not powered otherwise)*
	K1	P6 H8	Clocks – electronics
A	K1	P6 G8	Emergency evacuation – electronics *(non-freighter)*
A	K1	P6 J2	Equipment cooling differential press *(freighter)*
A	K1	P6 H6	Fire cargo main deck depressurization *(freighter)*
	K1	P6 H5	Fire extinguisher – APU
	K1	P6 H2	Fire extinguisher – engine 1 & 3 bottle A
	K1	P6 H1	Fire extinguisher – engine 1 & 3 bottle B
	K1	P6 H4	Fire extinguisher – engine 2 & 4 bottle A
	K1	P6 H3	Fire extinguisher – engine 2 & 4 bottle B
A	K1	P6 H6	Fire extinguisher – cargo lower *(combi & non-ER pax)*
A	K1	P6 D26	Fire extinguisher – cargo lower 1 *(freighter & ER pax)*
A	K1	P6 D27	Fire extinguisher – cargo lower 2 *(freighter & ER pax)*
A	K1	P6 H7	Fire extinguisher – cargo main deck *(combi)*
A	K1	P6 J2	Fire extinguisher – cargo main deck metered 1 *(combi)*
A	K1	P6 J3	Fire extinguisher – cargo main deck metered 2 *(combi)*
A	K1	P6 H7	Fire switch unlock solenoid *(non-combi)*
A	K1	P6 C6	Fire switch unlock solenoid *(combi)*
	K1	P6 G5	Fuel shutoff valve – APU
	K1	P6 G1	Fuel shutoff valve – engine 1
	K1	P6 G2	Fuel shutoff valve – engine 2
	K1	P6 G3	Fuel shutoff valve – engine 3
	K1	P6 G4	Fuel shutoff valve – engine 4
	direct	*direct*	Fueling *(can also be powered by ground handling bus)*
	K1	*o/s*	GCU 1 *(if not powered otherwise)*
	K1	*o/s*	GCU 2 *(if not powered otherwise)*
	K1	*o/s*	GCU 3 *(if not powered otherwise)*
	K1	*o/s*	GCU 4 *(if not powered otherwise)*
	direct	P6 E8	IRU C – DC *(during APU start)*
	direct	P6 E7	IRU L – DC *(during APU start)*
	direct	P6 E9	IRU R – DC *(during APU start)*
	K1	P6 G9	Overheat protection – main battery

o/s : Circuit breaker for this device is located outside the flight deck

Main Standby Bus – Equipment List:

Distribution CB on P6	Circuit breaker	
direct	P7 A10	ADC L
direct	P7 B20	ADF R
direct	P7 A12	AOA sensor L1
direct	P7 A13	AOA sensor L2
direct	P7 B10	ATC L – electronics
direct	P7 C2	CDU L – electronics
direct	P7 F11	EFIS control L – electronics
direct	P7 F8	EICAS display – upper
direct	P7 F9	EIU L
direct	P6 E1	Flap control – TE primary AC
direct	P7 C12	Flight controls electronics AC 1L
direct	P7 C10	Flight controls electronics AC 2L
direct	P7 A6	GPS L (MMR L)
direct	P7 A6	ILS L (MMR L)
direct	P7 A1	MAWEA power A
A *direct*	P7 A8	RMI L – electronics

(continued next page)

Main Standby Bus – Equipment List: *(continued)*

Distribution CB on P6	Circuit breaker	
direct	P6 L1	Standby lighting with dimmers fixed at 12 V: ATC lightplate [2], ACP lightplates [2], CDU L lightplate [2], clock L lighting [1], flood light – captain [2], glareshield lightplates [3], ISFD lightplate [1], overhead CVR monitor lighting [4], overhead air conditioning lightplate [5], overhead anti-ice switch shutters [4], overhead bleed air lightplate & switch shutters [5], overhead cabin altitude lightplate [1], overhead ELT lightplate [5], overhead fire lightplate [5], overhead ice and rain protection lightplate [1], overhead ignition and jettison lightplate [1], overhead ignition switch shutter [4], overhead IRS lightplate [4], overhead light control L lightplate [5], overhead light control R lightplate [5], overhead miscellaneous lightplate [5], overhead window heat switch shutters [1], RMI L lighting [1], RTP L lightplate [2], standby attitude/airspeed/altimeter lighting [1], standby compass lighting *(if controlled by captain)* [1], standby compass lighting *(if controlled by glareshield)* [3],
direct	P6 G19	Standby ignition – engine 1
direct	P6 G20	Standby ignition – engine 2
direct	P6 G21	Standby ignition – engine 3
direct	P6 G22	Standby ignition – engine 4
direct	P7 A9	VOR L & marker beacon

[1] *On this bus if AC bus 4 is unpowered or if P6 E19 is pulled*

[2] *On this bus if AC bus 4 is unpowered or if P6 E22 is pulled*

[3] *On this bus if AC bus 4 is unpowered or if P6 E21 is pulled*

[4] *On this bus if AC bus 4 is unpowered or if P6 E19 and E20 are pulled*

[5] *On this bus if AC bus 4 is powered and if P6 E19 is pulled*

Ground Handling Bus – Equipment List:

	Distribution CB on P6	Circuit breaker	
	o/s		BCU 1 *(if not powered otherwise)*
	o/s		BCU 2 *(if not powered otherwise)*
A	*direct*	P7 A25	Call panel electronics *(non-freighter)* **
A	*direct*	P7 A26	Call panel electronics *(freighter)* **
	o/s		Fuel control – boost pump AFT 2 ***
	direct	*direct*	Fueling *(if not powered by main hot battery bus)*
	o/s		GCU 1 *(if not powered otherwise)*
	o/s		GCU 2 *(if not powered otherwise)*
	o/s		GCU 3 *(if not powered otherwise)*
	o/s		GCU 4 *(if not powered otherwise)*
A	*direct*	P7 F3	HYDIM 1 *(can also be powered by DC bus 4)* *
	direct	P7 J3	HYDIM 4 *(can also be powered by DC bus 1)*
A	*direct*	*direct*	Tire pressure monitor *(can also be powered by DC bus 4)*

Cargo Handling Bus – Equipment List:

	Distribution CB on P6	Circuit breaker	
A	*o/s*		Nose door *(freighter)*
A	*o/s*		WBS *(can also be powered by ground service bus)*

o/s : Circuit breaker for this device is located outside the flight deck

* *On this bus if AUX 1 pump is installed*

** *If not powered otherwise*

*** *Can also be powered by DC bus 1*

Ground Service Bus – Equipment List:

Distribution CB on P6	Circuit breaker	
direct	P6 D23	Brake pressure indicator *(if not powered by towing bus)*
direct	P6 F24	Dome lights *(can also be powered by main battery bus)*
direct	P6 L31	Exterior lights – anti collision red
direct	P6 L32	Exterior lights – anti collision white
direct	*direct*	Exterior lights – landing light heat control
o/s		Exterior lights – logo
direct	P6 L28	Exterior lights – navigation lights system 1 & tail L
direct	P6 L29	Exterior lights – navigation lights system 2 & tail R
direct	P6 L33	Exterior lights – wing
direct	P6 L35	FMS database loader
o/s		Fuel boost pump AFT 2
o/s		Fuel transfer pump STAB L
o/s		Hydraulic pressure indication 4
direct	P6 K23	Stabilizer trim position indicator L
A *o/s*		WBS *(if not powered by cargo handling bus)*

28 V AC Main Bus – Equipment List:

Distribution CB on P6	Circuit breaker	
o/s		Hydraulic pressure indication 1
o/s		Hydraulic pressure indication 2
o/s		Hydraulic pressure indication 3
A24	P6 F23	Map lights
A24	P6 D1	Oil pressure indicator – engine 1
A24	P6 D2	Oil pressure indicator – engine 2
A24	P6 D3	Oil pressure indicator – engine 3
A24	P6 D4	Oil pressure indicator – engine 4
A24	P6 J24	Rudder & elevator sensors
A24	P6 J19	Rudder trim indicator
A24	P6 J20	Spoiler & aileron sensors
A24	P6 K24	Stabilizer trim position indicator R

o/s : Circuit breaker for this device is located outside the flight deck

Towing Power Bus – Equipment List:

Distribution CB on P6	Circuit breaker	
direct	*direct*	Flood light – captain *(if not powered otherwise)*
direct	*direct*	Hydraulic brake pressure indication lighting 12 V fixed
direct	*direct*	Navigation lights *(if not powered by ground service bus)*
direct	P6 L18	Parking brake control *(if not on main battery bus)*

Permanent Magnet Generators:

A permanent magnet generator (PMG) is installed in each of the four IDGs and in each of the two APU generators. A PMG, when rotated, can generate 100 V AC and provide this power to its associated generator control unit:

- When a generator control unit (GCU) of an engine is not powered by the main hot battery bus or ground handling bus, it is powered by its respective PMG.
- When an APU generator control unit (AGCU) is not powered by the main battery bus, it is powered by its respective PMG.

A generator control unit regulates the voltage and frequency of the respective IDG or APU generator, and provides various operative and protective functions.

External Power Receptacles:

An external power receptacle is powered whenever an external power is connected at the aircraft fuselage, even if the associated external power contactor (XPC) is open; that is, even if only the AVAIL light is illuminated. When a bus control unit (BCU 1 or BCU 2) is not powered otherwise, it uses the 115 V AC from an external power receptacle, and rectifies the current to DC internally:

- When BCU 1 is not powered by the APU hot battery bus or main battery bus or DC ground handling bus, it is powered by the EXT 1 receptacle.
- When BCU 2 is not powered by the APU battery bus or main hot battery bus or DC ground handling bus, it is powered by the EXT 2 receptacle.

The BCUs control the tie systems of the four AC and the four DC busses, and provide various operative and protective functions.

EICAS Messages:

CAUTION MESSAGES (accompanied by caution light and beeper sound)		
ELEC AC BUS ()	ISLN LIGHT OFF LIGHT	AC bus (1, 2, 3, or 4) is not powered
ELEC GEN OFF ()	OFF LIGHT	IDG (1, 2, 3, or 4) generator breaker is open while engine is running *[message inhibited by ELEC AC BUS ()]*

ADVISORY MESSAGES		
>BAT DISCH APU		APU battery is discharging *[message inhibited during APU start]*
>BAT DISCH MAIN		main battery is discharging
>BATTERY OFF	OFF LIGHT	battery switch is set to OFF
>DRIVE DISC ()		IDG (1, 2, 3, or 4) drive shaft is disconnected from engine gearbox and IDG frequency is below 200 Hz
ELEC BUS ISLN ()	ISLN LIGHT	bus tie breaker (1, 2, 3, or 4) is open *[message and light inhibited during autoland]* *[message inhibited by ELEC AC BUS ()]*
ELEC DRIVE ()		{ IDG (1, 2, 3, or 4) oil pressure is low OR oil temperature is above 185°C } AND engine is running AND drive is connected to gearbox
>ELEC SSB OPEN		split system breaker is open while commanded to close
ELEC UTIL BUS L	OFF LIGHT	at least one ELCU on AC bus 1 or 2 is unpowered due to a fault or manually switched off
ELEC UTIL BUS R	OFF LIGHT	at least one ELCU on AC bus 3 or 4 is unpowered due to a fault or manually switched off
>STBY BUS APU		APU standby bus is not powered
>STBY BUS MAIN		main standby bus is not powered
>STBY POWER OFF		standby busses are not powered

EICAS Messages:

STATUS MESSAGES		
BAT CHARGER APU		APU battery charger fault OR APU battery charger is not powered OR APU battery interlock is open OR APU battery overheat *[message inhibited if standby power selector in BAT position or if ground service bus unpowered]*
BAT CHARGER MAIN		main battery charger fault OR main battery charger is not powered OR main battery interlock is open OR main battery overheat *[message inhibited if standby power selector in BAT position or if ground service bus unpowered]*
CAPT XFR BUS		{ captain's transfer bus is set to AC bus 1 AND AC bus 3 is powered } OR { captain's transfer bus is set to AC bus 3 AND AC bus 3 is unpowered }
DRIVE DISC ()		IDG (1, 2, 3, or 4) drive shaft is disconnected from engine gearbox and IDG frequency is below 100 Hz
ELEC BCU ()		BCU (1 or 2) is inoperative OR no input to EIU from BCU via ARINC bus
ELEC DRIVE ()		IDG (1, 2, 3, or 4) overheat OR { IDG oil pressure is low AND engine is running AND drive is connected to gearbox }
ELEC TR UNIT ()		transformer rectifier unit (1, 2, 3, or 4) failure
F/O XFR BUS		{ first officer's transfer bus is set to AC bus 1 AND AC bus 2 is powered } OR { first officer's transfer bus is set to AC bus 2 AND AC bus 2 is unpowered }
STBY BUS APU		APU standby bus is not powered
STBY BUS MAIN		main standby bus is not powered
STBY INV APU		APU standby inverter is inoperative
STBY INV MAIN		main standby inverter is inoperative

Limitations in the Simulator:

The following status messages are not included as the respective malfunctions are not modeled: APU GEN 1, APU GEN COOLING, DRIVE () TEMP SNS, ELEC ARINC LINK, ELEC BTB (), ELEC GEN SYS (), ELEC IDG () VALVE.

Emergency Equipment

Aisle Stand:

A The evacuation signal system is installed on passenger and combi aircraft only.

Evacuation signal light & test switch

Push (momentary action) Tests the lamps and whether the system is powered. The power source is the main hot battery bus.

EVAC LIGHT Illuminates continuously during the test. Flashes continuously when the evacuation signal is active.

Evacuation signal horn

A continuous loop of beeps sound when the evacuation signal is on. *(In the simulator, the horn can be enabled on **Instructor > Preferences > Audio** with the **Evacuation horn** checkboxes.)*

Evacuation signal command switch (guarded)

There is one command switch on the flight deck and further switches at the cabin doors. *(In the simulator, the flight attendant's EVAC command switch at door 2L, respectively 1L, is represented on **Instructor** > **Situation** > **Human** > **Calls**.)*

ON Activates the signal in the cabin and on the flight deck.

ARM Allows the flight attendant's switch to activate the signal in the cabin and on the flight deck.

OFF Allows the flight attendant's switch to activate the signal on the flight deck only.

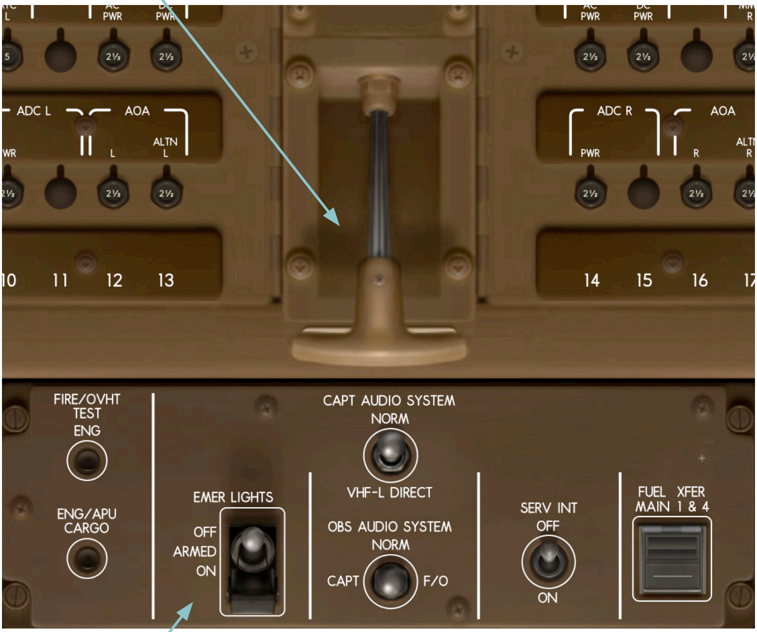
Horn shutoff switch

Push (momentary action) Silences the evacuation signal horn.

Overhead Panel:

Flight deck smoke evacuation handle

Pull Opens the smoke evacuation port in the roof above the flight deck. Discharges cabin air overboard if the cabin is pressurized.



Emergency lights switch (guarded)

The emergency light system contains its own dedicated batteries that provide power for at least 15 minutes. They are charged by DC bus 4. There is one emergency light switch on the flight deck and one at door 2L (or 1L) which can activate the emergency lights regardless of the switch position on the flight deck.

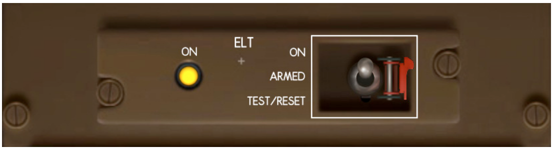
OFF Inhibits automatic activation of emergency lights which would occur when DC bus 4 is unpowered.

ARMED Illuminates all emergency lights automatically when DC bus 4 is unpowered.

ON Illuminates all emergency lights.

A Toggle switch directions are aircraft specific; the ON function may be in the upper or in the lower position.

Overhead Panel:



Emergency locator transmitter (ELT) switch
When activated, the ELT sends signals to an international satellite system for search and rescue (SAR) purposes. The system also transmits on 121.5 MHz and other frequencies. The ELT unit includes a non-rechargeable battery that provides transmission power for circa 50 hours *(in the simulator, the ELT battery can be replaced on* ***Instructor*** *>* ***Situation*** *>* ***Service*** *with the button* ***Service batteries****).*

ON (guarded)

Sends ELT signals continuously.

ARMED

Starts sending ELT signals automatically when a deceleration of 5 g or more is detected. *(In the simulator, the ELT is activated if the terrain closure rate at ground contact is 1500 fpm or more.)*

TEST/RESET

(momentary action) Resets the ELT when automatically activated. For the test, hold the toggle down for 2 seconds: if the ELT is operative, the light will blink 3 times within circa 6 seconds.

ON LIGHT

(blinking) ELT is transmitting.

Overhead Panel:

Passengers' oxygen *(non-freighter)*

Supernumaries' oxygen *(freighter)*

Cabin oxygen switch (guarded and wired)
*(In the simulator, the guard can be rewired on **Instructor** > **Situation** > **Service** with the button **Rewire switchguards**.)*

RESET
(momentary action) Closes the oxygen flow control if the cabin altitude is below 12000 ft.

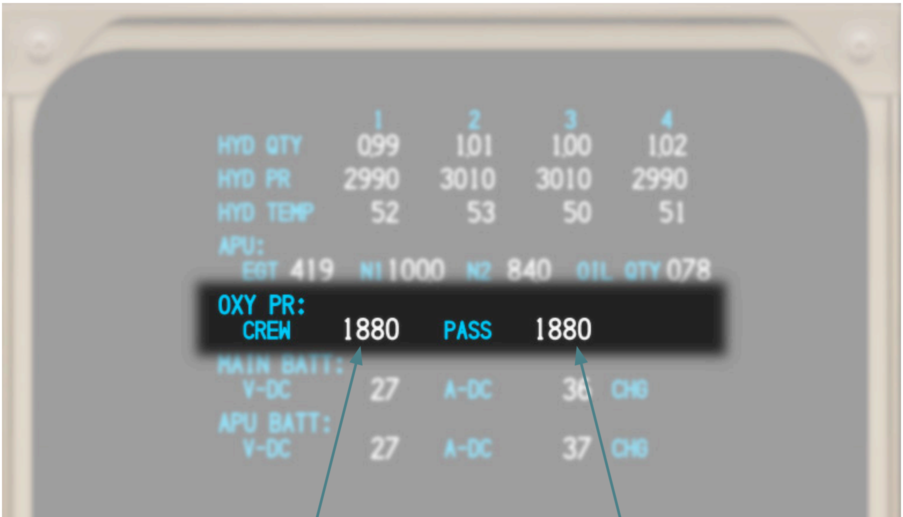
NORM
Arms the system to automatically drop the cabin oxygen masks when the cabin altitude is at or above 14000 ft.

ON
(momentary action) Commands the system to drop the cabin oxygen masks.

EICAS Status Display:

Status display switch

First push	Shows status display with oxygen indications on secondary EICAS display.
Second push	Blanks secondary EICAS display.



Oxygen pressure at the flight crew's oxygen cylinders.

Oxygen pressure at the supernumaries' *(freighter)* or passengers' oxygen cylinders.

(In the simulator, the emergency oxygen flow control can be closed and the oxygen cylinders can be refilled on ***Instructor > Situation > Service*** *with the button* ***Refill oxygen****.)*

EICAS Messages:

ADVISORY MESSAGES		
>CREW OXY LOW		flight crew oxygen pressure is at or below minimum
CREW RST OXY ON		crew rest oxygen system is active
>ELT ON		emergency locator transmitter is active
>EMER LIGHTS		emergency lights are activated by flight attendant OR emergency lights switch on flight deck is not in ARMED position
>PASS OXY LOW		passenger oxygen pressure is at or below 1600 psi
PASS OXYGEN ON		passenger oxygen system is active

STATUS MESSAGES		
PASS OXY REFILL		passenger oxygen pressure is at or below 1600 psi
PASS OXYGEN ON		passenger oxygen system is active

A On freighter aircraft, *passenger* oxygen messages refer to *supernumaries'* oxygen.

Fire Protection

System Overview:

The fire protection system includes fire detection, alerting, extinguishing, and system testing. In summary:

- **Dual loop overheat detectors** are installed on the engines.
- **Dual loop fire detectors** are installed on the engines and the APU.
- **Single loop fire detectors** are installed in all main gear wheel wells.
- A **Single loop overheat detectors** are installed in the cowls of the RR engine models.
- **Photo cell smoke detectors** are installed in the crew rest areas, lavatories, and cargo compartments.
- The **automatic fire/overheat logic & test system (AFOLTS)** is linked with the detectors and provides alert triggers and system tests.
- **Aural alerts** are provided by the MAWEA, visual alerts by the EICAS.
- **Manual fire extinguishing** controls are provided on the flight deck for the APU, the engines, and the cargo compartments.
- **Automatic fire extinguishing** is provided for the APU (on the ground) and for the lavatories.
- **Portable fire extinguishers** are available at various locations for extinguishing a fire in the passenger zones, crew rest areas, and on the flight deck.
- A **Main deck cargo compartment suppression** is a system installed on freighters only; fire will be extinguished by depressurizing the cabin.

When a wheel well fire occurs, it typically occurs after gear retraction during departure (after excessive use of wheel brakes during pre-takeoff operations). Such a fire can only be extinguished by extending the gear.

*(In the simulator, discharged fire extinguisher bottles can be replaced on **Instructor** > **Situation** > **Malfunctions** > **General** under **Reset: Malfunctions**.)*

Dual Loop Detectors:

There are various types of fire and overheat detector loops. Some loops contain pressurized gas and utilize pressure switches; other loops incorporate a bimetallic mechanism; or use a wire system whose electrical state varies with temperature. Each detector is connected to an associated electronic card in the AFOLTS assembly.

A The detector loop systems on the engines are engine model specific:

GE engine models are fitted with three dual loop fire detectors, and a dual loop overheat detector.

PW engine models are fitted with one dual loop fire detector, and a dual loop overheat detector.

RR engine models are fitted with a dual loop fire detector, a single loop cowl overheat detector, a dual loop strut overheat detector, and a dual loop turbine overheat detector.

The **APU compartment** contains one dual loop fire detector.

Normally, a fire or overheat detection on an engine is only valid when it is detected by both loops in the respective dual system. The loops are tested during every manual fire and overheat test on the overhead panel, and also automatically at power-up. When a loop does not pass the test, the dual system reconfigures for *single* loop operation, allowing a single loop to trigger an alert. When a loop fault occurs *after* the test so that the system stays in *dual* loop configuration, the remaining intact loop will not be able to trigger an alert as the system will consider it a false alert due to the missing output from the failed loop.

The APU dual loop, however, is permanently configured for single loop operation; an APU fire alert can be triggered by a single loop anytime.

Cargo Compartment Smoke Detectors:

The cargo smoke detectors apply the same dual validation logic as the engine loops do: normally, both sensors in a detector must sense smoke to trigger an alert unless the system is configured for single loop operation. The system can only configure itself for dual or single loop operation during manual tests or at power-up.

Fire Warnings:

When a fire is detected, the fire bell on the flight deck rings every five seconds. The first ring is louder than the subsequent rings. In case of an APU fire, the APU fire warning horn sounds also; the horn is installed in the right body gear wheel well. Both the bell and the horn can be silenced by extinguishing the APU fire, or by pulling the APU fire switch. In any case of a fire—in the APU, engine, cargo, or wheel well—, pushing a master warning reset switch silences the flight deck fire bell and turns off the master warning lights. Fire warnings are entirely reset when the respective fire is extinguished.

Fire warnings are inhibited during part of the takeoff: the inhibit starts at V1 if the FMC provides a valid V1 speed, else when the aircraft pitch rises through 5°. The inhibit ends after 25 seconds or when climbing through 400 ft.

Squibs and Fire Extinguisher Bottles:

Squibs are small, electrically triggered explosive devices mounted on the sealed outlets of the fire extinguisher bottles. When a squib detonates, it tears the outlet open, and pressurized halon gas in the bottle will discharge through a duct system into the area where the fire is located.

The main hot battery bus provides the trigger power; the power may be routed to a squib using the respective *fire* switch. Using a *test* switch on the maintenance panel, the power can be routed to the squib through a test lamp; the lamp acts as a resistor and reduces the current so that the squib will not explode during the test. Lights that do not illuminate during the test will indicate the respective power line to the squib is broken, or not powered, or the squib has been fired.

Each test switch refers to the squibs on the A or B engine bottles and the APU bottle,—or to cargo bottle squibs,—or to both. For example, on a non-ER passenger aircraft, test switch 1 refers to all *A* bottle squibs and all cargo bottle *forward* squibs; and test switch 2 refers to all *B* bottle squibs and all cargo bottle *aft* squibs. Other aircraft include two more test switches that refer to the cargo bottle squibs only.

The test light itself incorporates another switch; when that switch is pushed and the light does not illuminate, the test lamp is broken, or power is removed. That is a plain lamp test and cannot be influenced by a failed squib.

Maintenance Panel:

A Squib systems are aircraft specific.

Freighter & all ER aircraft

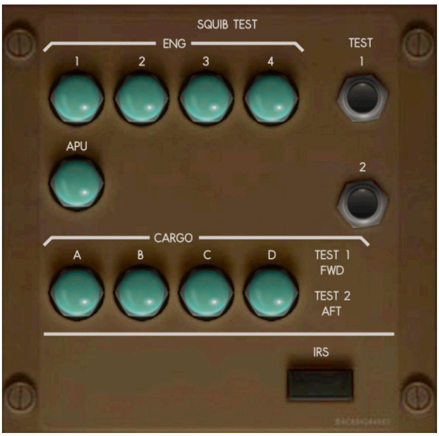
Squib test switch

Push (momentary action) Checks if the squibs in the respective test group are operative, and if trigger power is available. Do not push switches 1 and 2 (or 3 and 4) at the same time; it will invalidate the test.

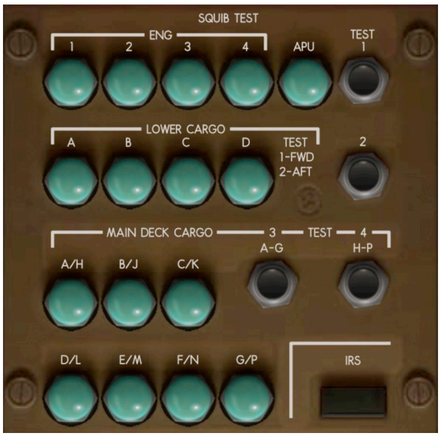
Squib test light & lamp test switch

Push (momentary action) Checks if the test lamp is intact, and if trigger power is available.

GREEN LIGHT During lamp test: indicates the test lamp is intact.
During squib test: indicates the squib system is intact.



Non-ER passenger aircraft



Combi aircraft

Overhead Panel:

Engine fire switch

Push Normal engine operation is enabled.

Pull (only possible when the override switch is pushed, or the red fire light is activated, or the fuel control switch is in CUTOFF)
- Closes the engine spar and fuel valves.
- Closes the engine bleed air PRSOV.
- Opens the IDG generator field.
- Opens the generator control breaker.
- Shuts off hydraulic fluid to the EDP.
- Arms the fire extinguisher squibs.
- Silences the fire bell.

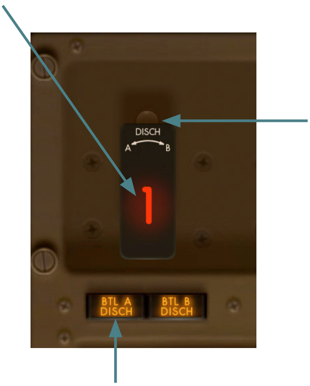
Rotate (springloaded to halfway-deflection) Ignites the squib to open the fire extinguisher bottle. The fire switch must be fully deflected into the A or B direction and held for circa one second. Once the A or B bottle is open, the bottle will automatically discharge all its content into the engine.

1,2,3,4 LIGHT A fire is detected in the engine, or the engine fire detection test is running and the detector is operative.

A Engine specific bottle systems:

GE & PW engines:
2 bottles per wing

RR engines:
2 bottles per engine



Override switch

Push & hold

(momentary action) Overrides the interlock behind the fire switch to allow the fire switch to be pulled. The interlock is removed automatically by a solenoid when the red fire light is activated, or when the fuel control switch is in CUTOFF.

(In the simulator, when the override switch is clicked with the mouse, the simulator will keep the override switch pushed for 2 seconds to allow the mouse to move on and click on the fire switch.)

Bottle discharged light
Illuminates when the fire extinguisher bottle is empty.

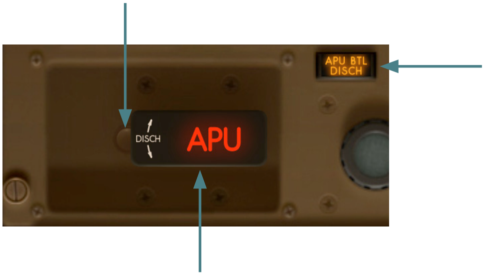
Overhead Panel:

Override switch

Push & hold

(momentary action) Overrides the interlock behind the fire switch to allow the fire switch to be pulled. When the APU fire light is activated, the interlock is removed automatically by a solenoid.

(In the simulator, when the override switch is clicked with the mouse, the simulator will keep the override switch pushed for 2 seconds to allow the mouse to move on and click on the fire switch.)



APU bottle discharged light
Illuminates when the APU fire extinguisher bottle is empty.

APU fire switch

Push Normal APU operation is enabled.

Pull (only possible when the override switch is pushed, or when the APU fire light is activated)
- Closes the APU fuel valve.
- Closes the APU bleed air valve.
- Shuts down the APU.
- Opens the APU generator field.
- Opens the APU generator breaker.
- Arms the APU fire extinguisher squib.
- Silences the fire bell and the APU fire warning horn.

Rotate (springloaded to halfway-deflection) Ignites the squib to open the fire extinguisher bottle. The fire switch must be fully deflected into one of the two directions and held for circa one second. Once the bottle is open, it will automatically discharge all its content into the APU compartment.

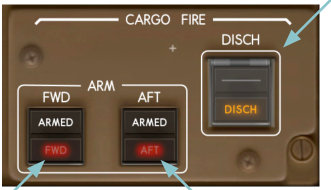
APU LIGHT A fire is detected in the APU compartment, or the APU fire detection test is running and the detector is operative.

Cargo Fire Control A *on Passenger Aircraft:*

Discharge switch

Push (momentary action) Discharges the A and B bottles into the armed compartment. After 30 minutes, or upon touchdown, the other armed bottles will discharge *(normally, the schedule varies by airline; the simulator applies this schedule on all aircraft)*.

DISCH LIGHT Discharge schedule is started.



Forward arm switch

ARMED Arms the lower forward cargo fire extinguisher squibs and reconfigures the air conditioning:
- Shuts down pack 3.
- Shuts down all equipment cooling fans, galley fans, gasper fans, lavatory fans, and recirculation fans.
- Sets the equipment cooling system to override mode.

blank Sets normal configuration.

FWD LIGHT A fire is detected in the lower forward cargo compartment, or the fire detection test is running and the detectors are operative.

Aft arm switch

ARMED Arms the lower aft cargo fire extinguisher squibs and reconfigures the air conditioning:
- Shuts down pack 3.
- Shuts down all equipment cooling fans, galley fans, gasper fans, lavatory fans, and recirculation fans.
- Sets the equipment cooling system to override mode.
- Deactivates the aft cargo heat.

blank Sets normal configuration.

AFT LIGHT A fire is detected in the lower aft cargo compartment, or the fire detection test is running and the detectors are operative.

Cargo Fire Control A *on Combi Aircraft:*

Main deck arm switch

ARMED Arms the main deck cargo fire extinguisher squibs and reconfigures the air conditioning:
- Shuts down pack 3.
- Shuts down all equipment cooling fans, galley fans, gasper fans, lavatory fans, and recirculation fans.

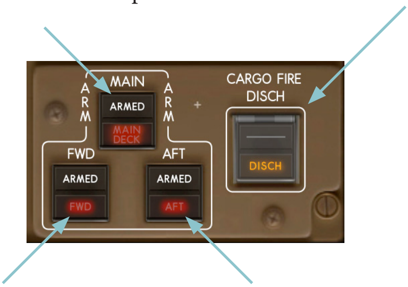
blank Sets normal configuration.

A fire is detected in the main deck cargo zone, or the fire detection test is running and the detectors are operative.

Discharge switch

Push (momentary action) Discharges the A and B bottles* into the armed compartment. After 30 minutes, or upon touchdown, the other armed bottles will discharge *(normally, the schedule varies by airline; the simulator applies this schedule on all aircraft).*

Discharge schedule is started.



* Applies if FWD or AFT is armed. If MAIN is armed, first discharges bottles A, B, C, and D, then the other armed bottles.

Forward arm switch

ARMED Arms the lower forward cargo fire extinguisher squibs and reconfigures the air conditioning:
- Shuts down pack 3.
- Shuts down all equipment cooling fans, galley fans, gasper fans, lavatory fans, and recirculation fans.
- Sets the equipment cooling system to override mode.

blank Sets normal configuration.

A fire is detected in the lower forward cargo compartment, or the fire detection test is running and the detectors are operative.

Aft arm switch

ARMED Arms the lower aft cargo fire extinguisher squibs and reconfigures the air conditioning:
- Shuts down pack 3.
- Shuts down all equipment cooling fans, galley fans, gasper fans, lavatory fans, and recirculation fans.
- Sets the equipment cooling system to override mode.
- Deactivates the aft cargo heat.

blank Sets normal configuration.

A fire is detected in the lower aft cargo compartment, or the fire detection test is running and the detectors are operative.

Cargo Fire Control A *on Freighter:*

Main deck arm switch

ARMED Arms the main deck fire suppression and reconfigures the air conditioning:
- Shuts down two packs.
- Sets equipment cooling to closed loop.
- Stops all airflow to the main and lower decks.
- Deactivates all cargo heat.

blank Sets normal configuration.

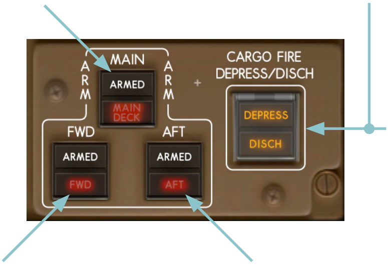
MAIN DECK LIGHT A fire is detected on the main deck, or the fire detection test is running and the detectors are operative.

Discharge switch

If FWD or AFT is armed:

Push (momentary action) Discharges the A and B bottles into the armed lower compartment. After 30 minutes, or upon touchdown, the other armed bottles will discharge *(normally, the schedule varies by airline; the simulator applies this schedule on all aircraft)*.

DISCH LIGHT Discharge schedule is started.



Depressurize switch

If MAIN is armed:

Push (momentary action) Raises the cabin altitude to 25000 ft.

DE-PRESS LIGHT Depressurization is started.

Forward arm switch

ARMED Arms the lower forward cargo fire extinguisher squibs and reconfigures the air conditioning:
- Shuts down two packs.
- Stops all airflow to the lower deck.
- Sets the equipment cooling system to override mode.
- Deactivates all cargo heat.

blank Sets normal configuration.

FWD LIGHT A fire is detected in the lower forward cargo compartment, or the fire detection test is running and the detectors are operative.

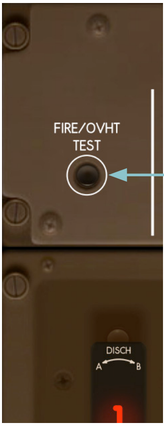
Aft arm switch

ARMED Arms the lower aft cargo fire extinguisher squibs and reconfigures the air conditioning:
- Shuts down two packs.
- Stops all airflow to the lower deck.
- Sets the equipment cooling system to override mode.
- Deactivates all cargo heat.

blank Sets normal configuration.

AFT LIGHT A fire is detected in the lower aft cargo compartment, or the fire detection test is running and the detectors are operative.

Fire and Overheat Test:

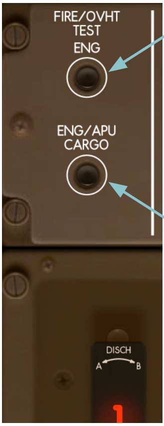


A Test systems are engine model specific.

Fire/overheat test switch
(GE & PW engines)

Push & hold

(momentary action) Initiates fire and overheat signals to test the detectors of the APU, bleed duct, cargo, engine, and wheel well systems. Checks the aural and visual alerts on the flight deck.



Engine fire/overheat test switch
(RR engines)

Push & hold

(momentary action) Initiates fire and overheat signals to test the engine turbine overheat detectors. Checks the aural and visual alerts on the flight deck.

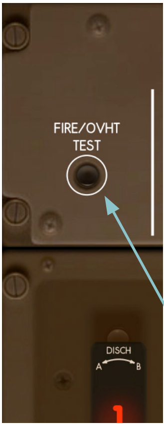
Engine, APU, cargo fire/overheat test switch
(RR engines)

Push & hold

(momentary action) Initiates fire and overheat signals to test the overheat detectors in the bleed ducts and engine struts and cowls, and to test the fire detectors on the engines, in the APU, the wheel wells, and cargo compartments. Checks the aural and visual alerts on the flight deck.

Fuel control switch fire light
Indicates a fire is detected in the engine, or the engine fire detection test is running and the detector is operative.

Valve Test:



The valve test is a function of the freighter system only.

Test switch

(FIRE/OVHT TEST switch if GE or PW engines are installed, else ENG/APU/CARGO switch.)

The valve test is disabled when the aircraft is in flight.

Push & hold

(momentary action) Keep the test switch pressed for at least 20 seconds to initiate the valve test program. The program will check all main deck cargo shutoff valves and the pack dump valves. The valves are used when the main deck fire suppression system reconfigures the air conditioning and starts depressurizing the cabin.

For valve test EICAS messages refer to the next page.

EICAS Messages:

	WARNING MESSAGES (accompanied by warning light and fire bell)		
	FIRE APU	APU LIGHT	fire detected in APU
	FIRE CARGO AFT	AFT LIGHT	smoke detected in lower aft cargo
	FIRE CARGO FWD	FWD LIGHT	smoke detected in lower forward cargo
	FIRE ENG ()	1,2,3,4 LIGHT FUEL SW	fire detected in engine (1, 2, 3, or 4)
A	FIRE MAIN DECK	MAIN DECK LIGHT	smoke detected in multiple main deck cargo zones *[freighter & combi aircraft]*
A	FIRE MN DK ()	MAIN DECK LIGHT	smoke detected in just one main deck cargo zone (AFT or MID or FWD) *[freighter]*
A	FIRE MN DK ()	MAIN DECK LIGHT	smoke detected in just one main deck cargo zone (AFT or MID) *[combi aircraft]*
	>FIRE TEST FAIL		at least one detection system has failed the test
	>FIRE TEST PASS		all detection systems are operative
	FIRE WHEEL WELL		fire detected in a main landing gear wheel well
	>TEST IN PROG		fire/overheat test is in progress
A	>VALVE TEST FAIL		at least one main deck cargo shutoff valve or pack dump valve has failed the valve test *[freighter]*
A	>VALVE TEST PASS		all main deck cargo shutoff valves and pack dump valves are operative *[freighter]*
A	>VLV TST IN PROG		main deck cargo shutoff valves and pack dump valves test is in progress *[freighter]*

EICAS Messages:

	CAUTION MESSAGES (accompanied by caution light and beeper sound)		
A	OVHT ENG () COWL		overheat detected in engine (1, 2, 3, or 4) cowl *[RR engines]*
	OVHT ENG () NAC		overheat detected in engine (1, 2, 3, or 4) nacelle
A	OVHT ENG () STRUT		overheat detected in engine (1, 2, 3, or 4) strut *[RR engines]*
A	OVHT MN DK CGO		flame or overheat in main deck cargo detected by thermal monitoring system *[combi aircraft]*
	>SMOKE CREW REST		smoke detected in crew rest
A	>SMOKE DR 5 REST		smoke detected in crew rest door 5 *[non-freighter]*
A	>SMOKE LAVATORY		smoke detected in lavatory *[non-freighter]*
A	>SMOKE ZN F REST		smoke detected in crew rest zone F *[non-freighter]*

	ADVISORY MESSAGES		
	>BOTTLE LOW APU	DISCH LIGHT	APU fire extinguisher bottle low pressure
A	>BTL LO () ENG ()	DISCH LIGHT	(L or R) wing engine fire extinguisher bottle (A or B) low pressure *[GE & PW engines]*
A	>BTL LOW ENG ()	DISCH LIGHT	engine fire extinguisher bottle (1A, 1B, 2A, 2B, 3A, 3B, 4A, or 4B) low pressure *[RR engines]*
	>BTL LOW CGO ()	DISCH LIGHT	cargo fire extinguisher bottle (A, B, C, or D) low pressure
A	>BTL LOW CGO ()	DISCH LIGHT	cargo fire extinguisher bottle (E or F) low pressure *[freighter, combi, & ER aircraft]*
A	>BTL LOW CGO ()	DISCH LIGHT	cargo fire extinguisher bottle (G, H, J, K, L, M, N or P) low pressure *[combi aircraft]*

(continued next page)

EICAS Messages:

(continued)

ADVISORY MESSAGES		
>CARGO DET AIR		insufficient vacuum for cargo smoke detection
>CGO BTL DISCH	DISCH LIGHT	{ any cargo fire extinguisher bottle low pressure AND aircraft on ground } OR { cargo fire extinguisher bottle A low pressure AND cargo fire exting. bottle B low pressure }
>DET FIRE APU		APU detector loops A and B for fire have failed
>DET FIRE/OHT ()		engine (1, 2, 3, or 4) detector loops A and B for fire or overheat have failed

	STATUS MESSAGES		
	AFT CARGO () LP ()		aft cargo zone (3 or 4) loop (A or B) fire or failure
	APU FIRE LOOP ()		APU fire loop (A or B) fire or failure
	BOTTLE LOW APU	DISCH LIGHT	APU bottle low pressure
	BTL LOW CARGO ()	DISCH LIGHT	cargo bottle (A, B, C, or D) low pressure
A	BTL LOW CARGO ()	DISCH LIGHT	cargo bottle (E or F) low pressure *[freighter, combi, & ER aircraft]*
A	BTL LOW CARGO ()	DISCH LIGHT	cargo bottle (G, H, J, K, L, M, N, or P) low pressure *[combi aircraft]*
A	BTL LOW () ENG ()	DISCH LIGHT	(L or R) wing engine bottle (A or B) low pressure *[GE & PW engines]*
A	BTL LOW ENG ()	DISCH LIGHT	engine bottle (1A, 1B, 2A, 2B, 3A, 3B, 4A, or 4B) low pressure *[RR engines]*
	CARGO DET AFT ()		aft cargo zone (3 or 4) loops A & B have failed
	CARGO DET FWD ()		forward cargo zone (1 or 2) loops A & B have failed
A	CGO DET () MN DK		main deck cargo zone (1, 2, 3, 4, 5, or 6) loops A & B have failed *[freighter & combi aircraft]*
A	CGO DET () MN DK		main deck cargo (7, 8, 9, 10, 11, 12, 13, 14, 15, or 16) loops A & B have failed *[freighter]*

(continued next page)

EICAS Messages:

(continued)

	STATUS MESSAGES		
	CGO DET AIR LWR		lower deck cargo photo cell smoke detection duct has insufficient vacuum
A	CGO DET AIR MD		main deck cargo photo cell smoke detection duct has insufficient vacuum *[freighter & combi aircraft]*
	ENG () FIRE LP ()		engine (1, 2, 3, or 4) fire loop (A or B) fire or failure
	ENG () OVHT LP ()		engine (1, 2, 3, or 4) overheat loop (A or B) overheat or failure
	FWD CARGO () LP ()		forward cargo (3 or 4) loop (A or B) fire or failure
A	MN DK CARGO () LP ()		main deck cargo (1, 2, 3, 4, 5, or 6) fire loop (A or B) fire or failure *[freighter & combi aircraft]*
A	MN DK CARGO () LP ()		main deck cargo (7, 8, or 9) fire loop (A or B) fire or failure *[freighter]*
A	MD CARGO () LP ()		main deck cargo (10, 11, 12, 13, 14, 15, or 16) fire loop (A or B) fire or failure *[freighter]*
	NAC TEMP ENG ()		engine (1, 2, 3, or 4) nacelle overheat OR nacelle temperatures disagree between engines
A	STRUT OVHT () LP()		engine (1, 2, 3, or 4) strut overheat loop (A or B) overheat or failure *[RR engines]*
A	TURB OVHT () LP ()		engine (1, 2, 3, or 4) turbine overheat loop (A or B) overheat or failure *[RR engines]*

Limitations in the Simulator:

Fire simulations are not available for the mid and forward main deck, the lavatories, and crew rests. Overheat simulations are not available for the struts and cowls. However, EICAS messages may appear when the respective systems are unpowered.

Flight Controls

For hydraulic system distribution, refer to chapter **Hydraulics**.
For stick shaker system, refer to chapter **Warning Systems**.

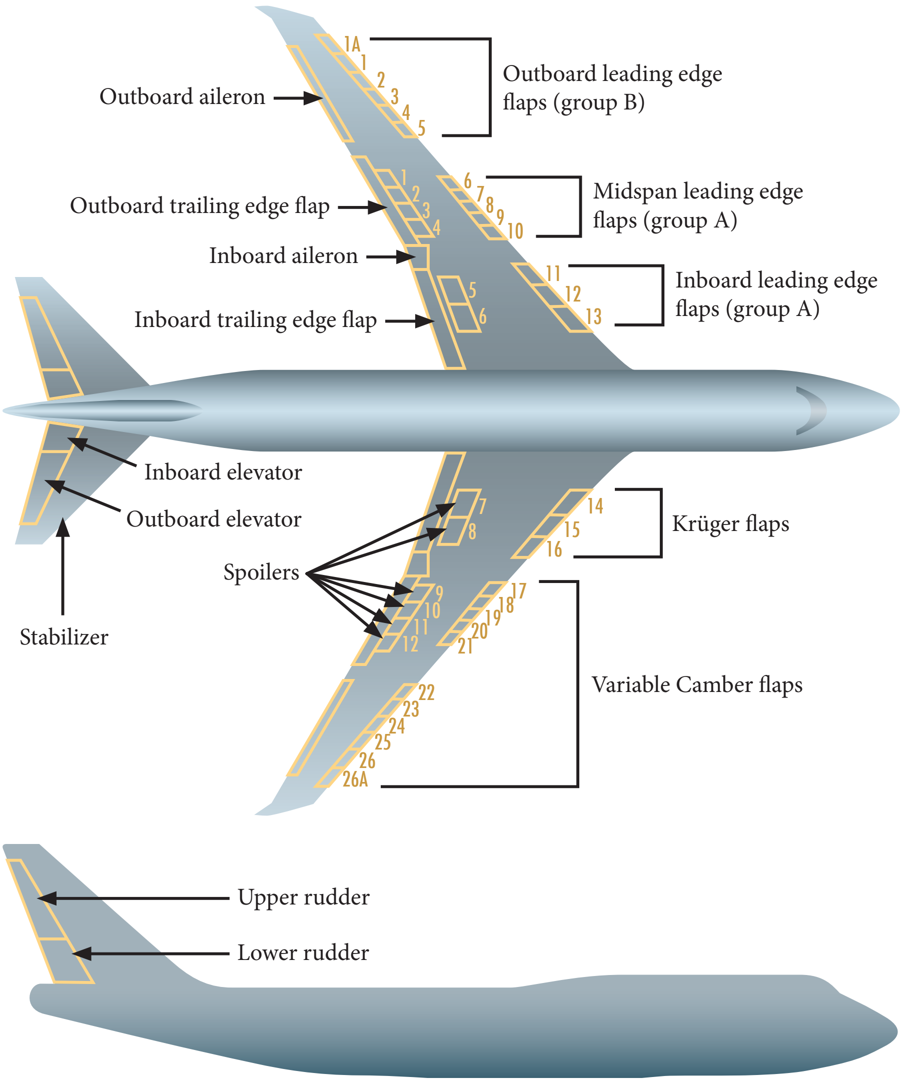
System Overview:

The flight control system comprises the following control surfaces:

- **Ailerons**—redundantly driven by multiple hydraulic systems. The associated aileron trim is electrically driven.
- **Elevators**—redundantly driven by multiple hydraulic systems. There is no elevator trim.
- **Rudders**—redundantly driven by multiple hydraulic systems. The associated rudder trim is electrically driven.
- **Spoilers** support the ailerons about the roll axis, or are utilized as speedbrakes. Spoilers are hydraulically driven. The speedbrake lever on the flight deck may operate electrically.
- A **horizontal stabilizer** provides pitch trim; it is redundantly driven by two hydraulic systems.
- **Flaps** can enlarge the wing area by circa 21%, increasing the lift by circa 90%. Primarily, the leading edge flaps are moved by pneumatic drives, and the trailing edge flaps by hydraulic drives. All flaps can be moved electrically when the primary drives fail.

*(In the simulator, the flight controls can be operated by mouse, keyboard, TCP/IP network, or USB devices. For more information refer to chapter **Simulator Handling**.)*

Flight Control Surface Locations:



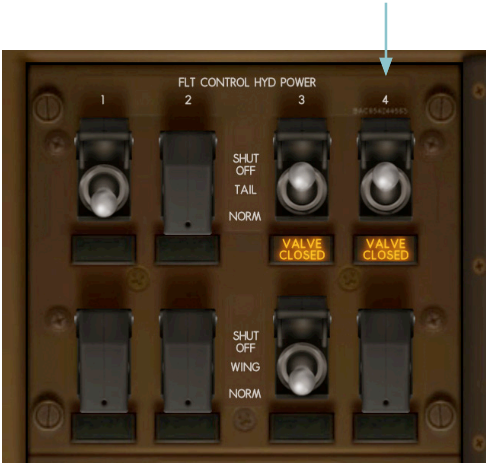
Maintenance Panel:

Flight control shutoff switch (guarded)
(tail 1, 2, 3, 4; wing 1, 2, 3, 4)

SHUTOFF
Closes the shutoff valve of the respective flight controls to disconnect them from the associated hydraulic system for maintenance works.

NORM
Opens the respective shutoff valve for normal flight control operation.

VALVE CLOSED LIGHT
The shutoff valve is closed.



A Toggle switch directions are aircraft specific; the NORM function may be in the upper or in the lower position.

Tail 1 *(hyd. system 1)*:	Upper rudder; left outboard & left inboard elevator.
Tail 2 *(hyd. system 2)*:	Lower rudder; left inboard elevator.
Tail 3 *(hyd. system 3)*:	Upper rudder; right inboard elevator.
Tail 4 *(hyd. system 4)*:	Lower rudder; right outboard & right inboard elevator.

Wing 1 *(hyd. system 1)*:	Left outboard & left inboard ailerons.
Wing 2 *(hyd. system 2)*:	Left outboard & right inboard ailerons; spoilers 2, 3, 10, 11.
Wing 3 *(hyd. system 3)*:	Left inboard & right outboard ailerons; spoilers 1, 4, 9, 12.
Wing 4 *(hyd. system 4)*:	Right inboard & right outboard ailerons; spoilers 5, 6, 7, 8.

Overhead Panel:

Yaw damper switch (upper, lower)

ON The respective yaw damper is operative.

INOP LIGHT The respective yaw damper is inoperative.

Aisle Stand:

OFF flag
Rudder trim *indicator* is inoperative (trim *control* may be operative).

Rudder trim indicator
Indicates units of trim.

Rudder trim switch
(Rudder trim is limited to 80% of full rudder travel.)

22° switch position left or right
Rudder trim moves at *low* speed in the selected direction.

45° switch position left or right
Rudder trim moves at *high* speed in the selected direction. *(In the simulator, the high speed switch position can be set by pushing both mouse buttons).*

(Normally, the two-speed rudder trim control is optional. In the simulator, it is installed on all aircraft.)

A **Rudder trim centering switch**

Push (momentary action) Commands the rudder trim to move to the center. Can be stopped by rotating the rudder trim switch.

CTR LIGHT The rudder trim is moving to the center.

Aisle Stand:

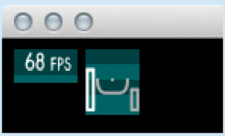
(In the simulator, the control wheels are not visualized. Aileron trim units are normally indicated on the control wheels. The simulator indicates them at the aileron trim switches for one second when the mouse hovers over the switches, or when the trim moves.—When the trim is less than 0.07 units, the trim will center itself to 0.00.)

Aileron trim switch
(Aileron trim can rotate the control wheel to a maximum of 47° to the left or right; this corresponds to 6 trim units.)

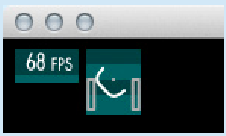
Push both switches to the left or to the right
Aileron trim moves in the selected direction. The driving force of the aileron trim mechanism is limited; therefore, extreme trim settings must be supported by rotating the control wheel during trimming *(in the simulator, this effect can be disabled on* ***Instructor*** *>* ***Preferences*** *>* ***Basics*** *by deselecting the checkbox* ***Aileron trim requires manual assistance****).*

Simulator specific indication in the upper left frame corner

The indication can be activated on **Instructor** > **Preferences** > **Basics** with the checkbox **Show info tags**.—Indication examples:



Left rudder pedal pushed. If white: Trim neutral.



Aileron control turned right. If white: Trim neutral.

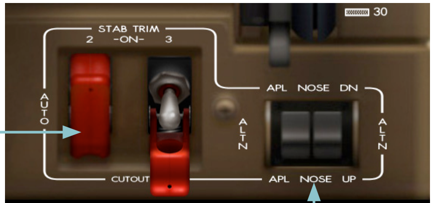
Left rudder pedal pushed. If yellow: Trim out of neutral.

Aileron control turned right. If yellow: Trim out of neutral.

Aisle Stand:

Stabilizer trim indicator
The white band indicates the stabilizer angle of incidence in units of trim. The green band segments indicate the trim range allowed for takeoff: The green mid segment is always displayed; the nose down segment or the nose up segment is displayed automatically when the gross weight and CG values entered in the FMC result in the respective range selection. The system warns if the entered CG is outside the CG range detected by the pressure switch on the nose gear oleo.

OFF flag
Stabilizer trim *indicator* is inoperative (stabilizer *control* may be operative).



Stabilizer trim cutout switch (2, 3) (guarded)

ON
Connects hydraulic system 2 (or 3) to the stabilizer system.

AUTO
Same as ON, but disconnects when uncommanded trim motion is detected.

CUTOUT
Disconnects hydraulic system 2 (or 3) from the stabilizer system.

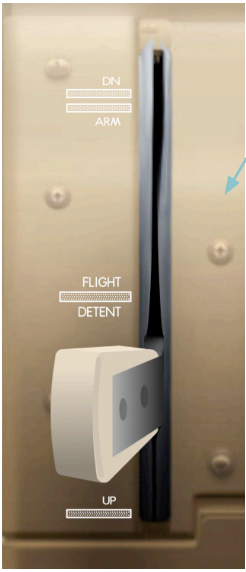
Alternate stabilizer trim switch

Push both switches up or down
The alternate control trims the stabilizer in the selected direction. Overrides the trim commands of the autopilot, but will not disengage the autopilot.

Normal Stabilizer Trim Switches:

Stabilizer trim switches are installed in the control wheels. The trim rate is airspeed dependent; also, the trim rate is reduced by 50% when it is driven by just one hydraulic system. The trim range of the normal trim is smaller than that of the alternate trim.

Aisle Stand:



Speedbrake lever

DN

Retracts all spoiler panels. On the ground, when reverse thrust lever 2 or 4 is raised while throttles 1 and 3 are at idle, the speedbrake lever will move to the UP position and fully extend all spoiler panels. The lever automatically moves to DN when throttle 1 or 3 is moved out of idle.

ARM

Arms automatic spoiler extension for landing. At touchdown, when throttles 1 and 3 are at idle, the speedbrake lever will move to the UP position and fully extend all spoiler panels.

FLIGHT DETENT

Maximum permitted spoiler extension when the aircraft is in flight.

UP

Applicable on the ground only. Fully extends all spoiler panels.

Flaps 1 gate

Helps avoiding:

- Unintentional retraction of remaining leading edge flaps.
- Unintentional extension of trailing edge flaps before group A leading edge flaps are extended.

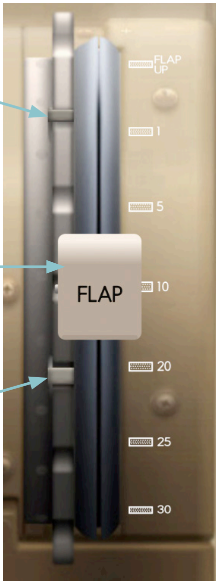
Flap lever

Commands flap position if flaps control is not in alternate mode.

Flaps 20 gate

Helps avoiding:

- Unintentional retraction of landing flaps past flaps 20 when initiating a go-around.
- Unintentional extension of landing flaps before gear is down.

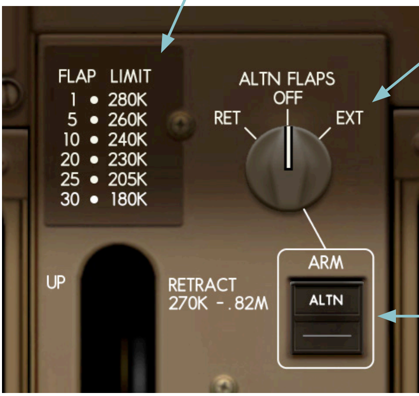


Main Instrument Panel:

ER aircraft:

A **Flap limit placard**
Shows IAS limits for flap settings.

Non-ER aircraft:



Alternate flaps selector

RET Retracts the flaps using electric drives.

OFF Stops alternate flap motion.

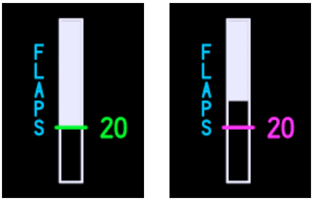
EXT Extends the flaps using electric drives. Maximum is flaps 25.

Alternate flaps arm switch

ALTN Arms the alternate flaps control, deactivates pneumatic and hydraulic flap drive controls, and disables the flap lever. Shows the alternate flaps indication on the upper EICAS display. Flap asymmetry protection is not available.

Flap Indication when in Primary Mode:

Displayed when any flap is out and the flap system is operating normally. The white tape indicates the position of the slowest flap. The flap lever position is indicated by a green line when the lever position agrees with the flap position, or by a magenta line when the flaps are in transit. When all flaps are up, the entire indication blanks after 10 seconds.



For Engineers

White tape indication

Leading edge flap position sensors provide signals for just three states: retracted, in transit, and extended. Therefore, when the leading edge flaps are in transit between UP and 1, the white tape does not move gradually; it is *fixed* halfway between UP and 1 until the commanded target position is reached.

Whereas the position of the slowest *trailing edge* flap is indicated *gradually* when in transit. However, when the slowest trailing edge flap is within a certain tolerance of the commanded position, the tape will jump directly to that commanded position. Selecting another flap position in this moment will cause the white tape to show the actual flap position again. That is, the white tape may momentarily jump in the opposite direction when another flap position is commanded before the flaps have actually reached the previous target position.

Flap Indication when in Secondary Mode:

Displayed when a fault is detected in the primary flaps control.

Leading edge flap group is in transit.

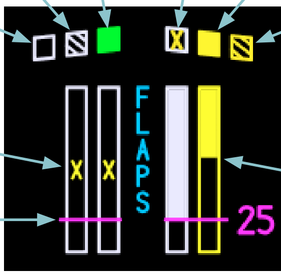
Leading edge flap group is extended.

Leading edge flap position sensor is inoperative.

Leading edge flap group stays extended while commanded to retract.

Leading edge flap group is up. If outline is amber: No flap motion while commanded to extend.

Leading edge flap group is stuck in transit while commanded to move.



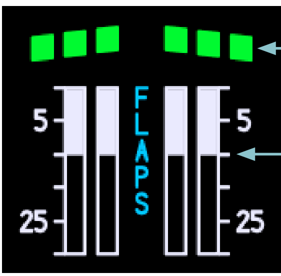
Trailing edge flap position sensor is inoperative.

Position of trailing edge flap group. If amber: Asymmetry or drive failure is detected.

Flap lever. If green: Lever position agrees with flap positions.

Flap Indication when in Alternate Mode:

Displayed when the alternate flaps control is armed.



Leading edge flap group position indication.

Trailing edge flap group position indication.

Surface Position Indication on Secondary EICAS Display:

Engine display switch

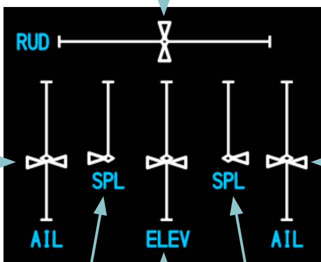
Push Shows engine display with flight control surface position indication. A

Status display switch

Push Shows status display with flight control surface position indication. A

Upper and lower rudder positions.

Left inboard and left outboard aileron positions.



Right inboard and right outboard aileron positions.

Spoiler panel 4 position.

Spoiler panel 12 position.

Left and right outboard elevator positions.

Elevator Control:

The pilots' control columns are mechanically interconnected with each other on the flight deck. Two cable loops mechanically transfer the joined column motion to hydraulic **power control packages (PCPs)** located in the tail of the aircraft. The PCPs provide the variable hydraulic power to move the elevator surfaces. Also located in the tail are the autopilot actuators; they too provide mechanical inputs to the PCPs, and at the same time move the control columns on the flight deck via the cable loops.

An **elevator feel** unit in the aircraft tail provides a centering force and artificial feel to the elevator control system. The feel system is controlled by the elevator feel computer. The commanded centering force is a function of the current equivalent airspeed (EAS) and—indirectly—the center of gravity (CG) which is derived from the stabilizer trim setting: the computer assumes the CG to be the more aft, the farther the trim is set nose down. The aerodynamic effect of the elevator is more dominant when the CG is more aft; hence, to prevent excessive pilot inputs, the computer increases the centering force accordingly. The same principle applies when the EAS increases. The feel function is fully operative when hydraulic system 2 or 3 is pressurized. When both hydraulic systems fail, mechanical springs provide a constant centering force.

SYSTEM ANALYSIS

In the simulator, the current elevator feel pressure is indicated on **Instructor** > **Analysis** > **Miscellaneous**. The value is also accessible through the simulator's main network.

Stabilizer Trim:

The aircraft pitch attitude is trimmed by changing the horizontal stabilizer's angle of incidence. Hydraulic systems 2 and 3 move the trim mechanism. If just one system is pressurized, the trim moves at half rate. The trim system is controlled through **normal** and **alternate** control channels. When the normal channel is in use, the trim rate is airspeed dependent: the rate is high when the airspeed is low. When the *alternate* control is applied, the trim moves at the highest possible rate. Trim rates, trim limits, protections, and other functions are controlled by two **stabilizer trim & rudder ratio changer modules (SRMs)** labeled as SRM L and SRM R.

The normal channel is linked with the trim switches in the pilots' control wheels; the alternate channel is linked with the alternate trim switches on the aisle stand. The stabilizer will not move when two pairs of trim switches are pushed in opposite directions, or when the normal trim switches and the control columns are pushed in opposite directions.

When the normal trim switches are pushed during single autopilot operation, the autopilot will disengage. During multi-channel autopilot operation, the normal trim switches are disabled and the autopilots will not disengage. The *alternate* trim switches always override the trim commands of the autopilots, but will not disengage the autopilots.

The control system includes an automatic **speed trim** function which improves the airspeed stability in certain flight phases. Typically, when the airspeed rises, the aircraft will increase pitch on its own and will climb, which in return will decrease the airspeed and thus restabilize it. Under certain conditions, however, the aircaft is not able to induce sufficient nose up momentum on its own. To compensate this problem, the speed trim function will—to a certain degree—move the stabilizer in the nose up direction when the airspeed rises. Speed trim is active when all of the following conditions are true:

+ 20 seconds have passed since liftoff.
+ Pilot is not trimming the stabilizer.
+ Autopilots are disengaged.
+ Flap lever is not set to 25 and not set to 30.
+ IAS is between 120 and 220 kt.
+ SRM L and hydraulic system 2 are operative; or SRM R and hydraulic system 3 are operative.

A Freighters also have a **Mach trim** function that compensates effects caused by the shorter, freighter specific upper deck. Mach trim starts at Mach 0.86, leading to a stabilizer position change of 0.5° at Mach 0.9 *(too small to be noticable in the simulator)*.

Aileron Control:

Roll control— respectively, lateral control—is provided by inboard and outboard aileron surfaces and various spoiler panels. They are controlled by turning either of the two control wheels on the flight deck. The two control wheels are mechanically interconnected; however, if one wheel jams, the other unjammed wheel may move independently when significant manual force is applied. Two cables mechanically transfer the control wheel motion to **central lateral control packages (CLCPs)** located in the wing gear wheel wells. CLCPs and aileron programmers convert the pilot inputs to the respective mix of surface position commands. These commands are transferred to hydraulic PCPs located in the wings. The PCPs position the ailerons and spoilers. The wing gear wheel wells also contain three autopilot servos for lateral control which too provide mechanical inputs to the CLCPs, and at the same time move the pilots' control wheels through the mechanical cable system.

The aerodynamic roll control sensitivity increases with airspeed. At high airspeeds, to avoid overcontrolling, the **aileron lockout** system keeps the outboard aileron surfaces in the neutral position. The lockout process starts when the group A leading edge flaps are retracted, and the airspeed rises above 238 kt or above Mach 0.53. The lockout process will take circa 30 seconds. During this process, the outboard aileron deflection ratio will gradually decrease from 100% to 0%. The reversed process will start when the group A leading edge flaps are extended, or when the airspeed is below 232 kt and below Mach 0.51. The aileron lockout system is controlled by the SRMs.

Spoiler Control:

Six spoilers are installed on the upper surface of each wing. They are numbered from 1 to 12, starting from the left. All spoilers, except for number 6 and 7, support the ailerons for lateral control. The inboard spoilers 3 through 10 also act as speedbrakes when the speedbrake lever is extended. Spoiler mixers control the respective ratio between aileron support and speedbrake function. On the ground, all spoilers can be fully extended.

Rudder Control:

Yaw control is provided by the upper and lower rudder surfaces on the vertical stabilizer. They are controlled by pushing the rudder pedals on the flight deck. Pedal motion is mechanically transferred via cables to the aircraft tail where the system is linked with a feel and trim mechanism. Two ratio changers in the tail control the upper and lower rudder hydraulic actuators. The SRMs compute the ratio; it gradually decreases with the rising airspeed. Rudder autopilot servos provide autocontrol during autoland and multi-channel go-around.

The **yaw damper** system increases the directional stability of the aircraft. Both the upper and lower yaw dampers are active when the aircraft is airborne.

Flaps Control:

The flap lever angle is sensed by three **rotary variable differential transformers (RVDTs)** which are monitored by three **flap control units (FCUs)**. At least one RVDT and one FCU must be operative to provide flap lever control. The FCUs operate either in primary mode or in secondary mode. In primary mode, the leading edge (LE) flaps are moved by pneumatic drives, and the trailing edge (TE) flaps are moved by hydraulic drives. When a flap does not reach the commanded position within a specific time, the FCUs automatically switch to secondary mode. In that mode, the entire group, to which the failed flap belongs, will be symmetrically moved by electric drives. When an electric drive fails as well, and the LE flaps are asymmetrically extended, the respective LE groups on both wings are stopped. TE flaps incorporate a mechanical asymmetry protection: the left wing inboard TE flaps are interconnected with the right wing inboard TE flaps; and the left wing outboard TE flaps are interconnected with the right wing outboard TE flaps.

The LE flaps in the midspan and inboard sections are labeled as group A; and the outboard LE flaps as group B. In primary mode, group A extends when the flap lever is set to 1. When the lever is set to 5, group B extends and the TE flaps start to extend.—The retraction is scheduled as follows: When the flap lever is set from 5 to 1, the TE flaps are commanded to retract completely, and during the retraction, when the inboard TE flaps pass 4.5 units, group B starts to retract. When the flap lever is set to UP and the outboard TE flaps are up, group A starts to retract.

When the alternate mode is activated on the main instrument panel, the FCUs are bypassed and a simplified retraction and extension control commands the electric drives.

The FCUs provide a **flap load relief** function. When the flaps are manually set to 25 or 30, and the flap limit speed of the respective aircraft model is exceeded, the FCUs automatically retract the flaps to the next best flap position, but to not less than flaps 20.

EICAS Messages:

CAUTION MESSAGES (accompanied by caution light and beeper sound)		
FLAPS CONTROL		alternate flaps control activated OR all RVDTs are unpowered OR all FCUs have failed
FLAPS DRIVE		any flap drive has failed in secondary mode *[message inhibited by FLAPS CONTROL]*
FLAPS PRIMARY		leading edge flap pneumatic drive failure OR trailing edge flap hydraulic drive failure *[message inhibited by FLAPS CONTROL or FLAPS DRIVE]*
SPEEDBRAKE EXT		speedbrake lever is out of ARM position AND radio altitude is above 15 ft AND { at least two thrust levers are out of idle by 5° or more OR landing flaps are set OR radio altitude is below 800 ft }
STAB TRIM UNSCHD		unscheduled stabilizer trim motion is detected

ADVISORY MESSAGES		
AILERON LOCKOUT		aileron lockout disagrees with commanded position
>FLAP RELIEF		flap load relief function has retracted the flaps
>FLT CONT VLVS	VALVE CLOSED LIGHT	any flight control shutoff valve is closed
RUD RATIO DUAL		upper and lower rudder ratio systems have failed
RUD RATIO SNGL		one rudder ratio system has failed
SPEEDBRAKE AUTO		autospeedbrake disagrees with commanded position
>STAB GREENBAND		nose gear oleo pressure switch disagrees with FMC selected takeoff trim data
>STAB TRIM ()		hydraulic system (2 or 3) stabilizer drive failure causing the stabilizer trim rate to be reduced by 50%
>YAW DAMPER ()	INOP LIGHT	yaw damper (LWR or UPR) failure

EICAS Messages:

STATUS MESSAGES		
AILERON LOCKOUT		aileron lockout disagrees with commanded position
ELEVATOR FEEL		excessive disagreement between left and right elevator feel system *[message inhibited when hydraulic system 2 or 3 pressure is below 1200 psi]*
FLAP CONTROL ()		FCU (L, C, or R) failure
FLAP LOAD RELIEF		flap load relief function failure
FLAP SYS MONITOR		FCU failure or sensor fault
LE MULT DRIVE		multiple leading edge flap drives have failed
LE SINGLE DRIVE		one leading edge flap drive has failed
A MACH/SPEED TRIM		speed trim and Mach trim function has failed *[freighter]*
RUDDER RATIO		upper or lower rudder ratio function failure
RUD TRIM CTR		fault detected in rudder trim autocentering control
SPEEDBRAKE AUTO		autospeedbrake disagrees with commanded position
STAB AUTO CUTOUT		automatic stabilizer cutout function has failed
STAB AUTO TRIM		stabilizer autotrim function has failed
STAB GREENBAND		nose gear oleo pressure switch disagrees with FMC selected takeoff trim data
A STAB SPEED TRIM		speed trim function has failed *[passenger & combi aircraft]*
STAB TRIM		hydraulic system (2 or 3) stabilizer drive failure causing the stabilizer trim rate to be reduced by 50%
STAB TRIM UNSCHD		unscheduled stabilizer trim motion is detected
TE FLAPS		trailing edge flap system failure
YAW DAMPER ()	INOP LIGHT	yaw damper (LWR or UPR) failure

Flight Instruments

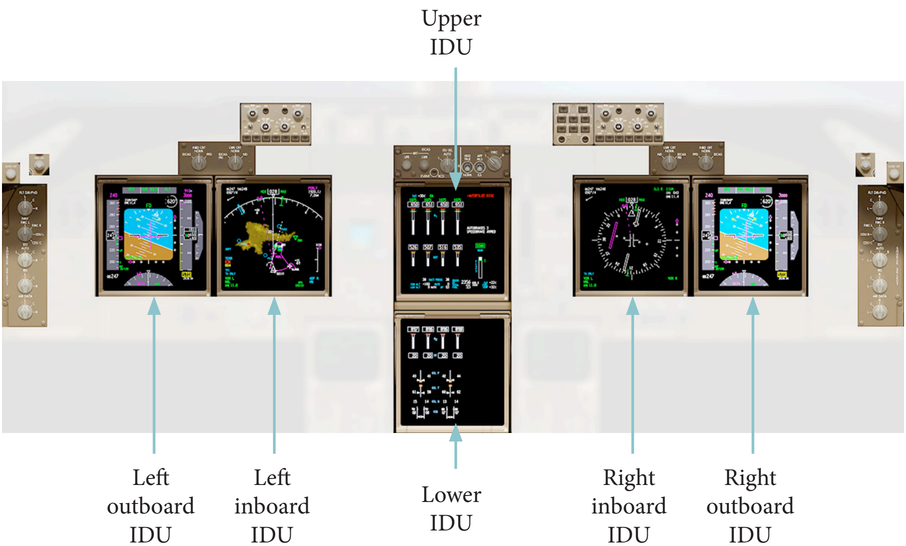
Integrated Display System:

The **integrated display system (IDS)** comprises six **integrated display units (IDUs)**. Each IDU integrates a display and various components for graphics processing, display control, and hardware protection. The IDS includes the **electronic flight instrument system (EFIS)**, and the **engine indication & crew alerting system (EICAS)**. An IDU can provide one of the following display functions:

- EFIS **primary flight display (PFD)**
- EFIS **navigation display (ND)**
- Primary EICAS display
- Secondary EICAS display

For EICAS symbology refer to chapter **Warning Systems**.

In older IDUs the integrated display is a **cathode ray tube (CRT)**; newer IDUs provide a **liquid crystal display (LCD)** and a slightly modified layout of the screen symbology.



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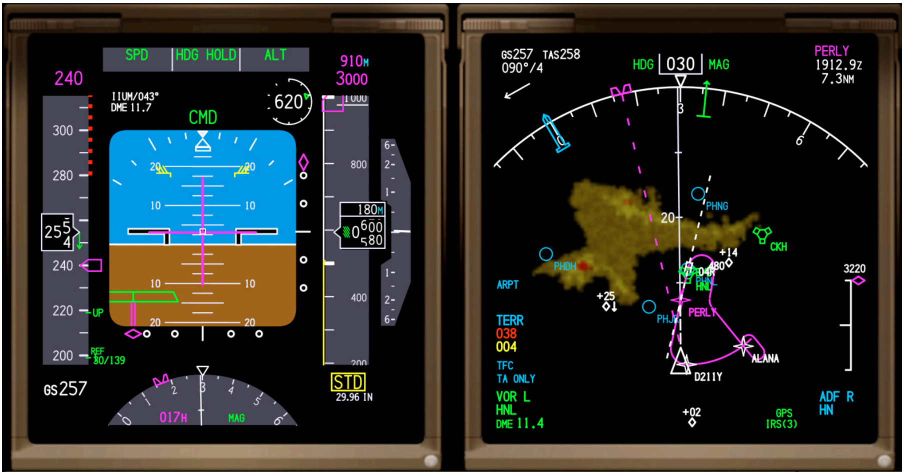
Integrated Display System: *(continued)*

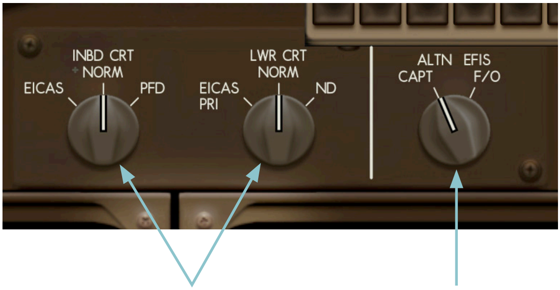
CRT version of PFD and ND:

LCD version of PFD and ND:



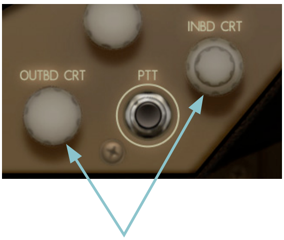
IDU Controls:

Selectors are labeled with “CRT” even if LCD type IDUs are installed; the panel lettering has not been amended since the introduction of the LCD version. “CRT” actually refers to “IDU”.

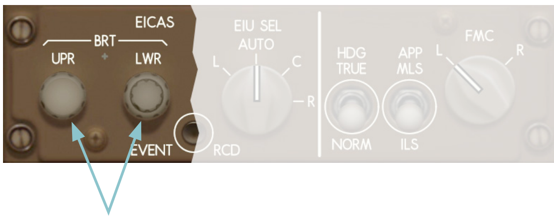


Captain’s IDU selectors
(First officer’s selectors are similar) Assign EFIS/EICAS display functions to the inboard IDU and lower IDU. For configuration examples refer to the next pages.

A **Alternate EFIS selector**
Refer to chapter **Electrical**.

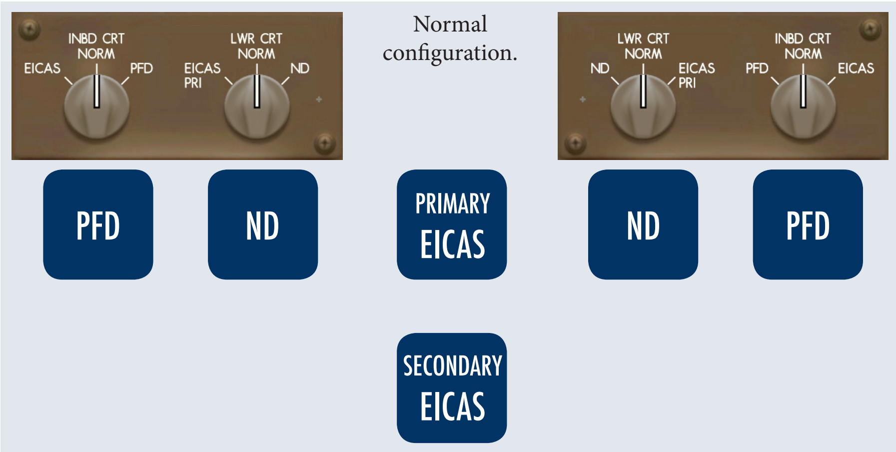


Captain’s IDU brightness controls
(First officer’s controls are similar) Set the brightness and stroke (line width) of the graphics on the outboard and inboard IDUs. The inner knob of the inboard control sets the brightness of the weather radar and terrain images.

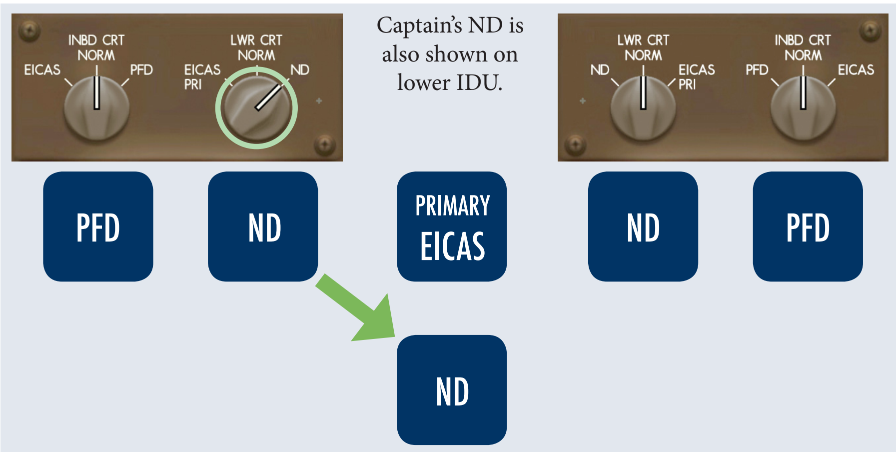


Upper & lower IDU brightness controls
Set the brightness and stroke (line width) of the graphics on the upper and lower IDUs. The inner knob of the lower control sets the brightness of the weather radar and terrain images.

IDU Switching:



Normal configuration.



Captain's ND is also shown on lower IDU.

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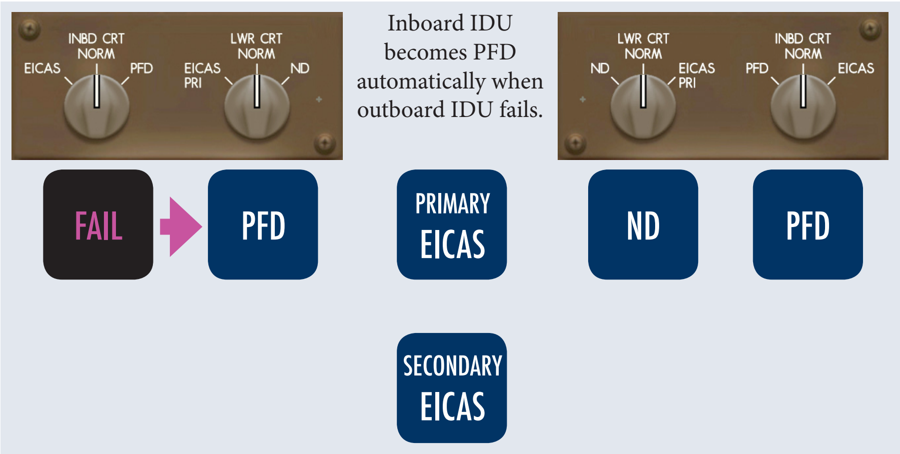
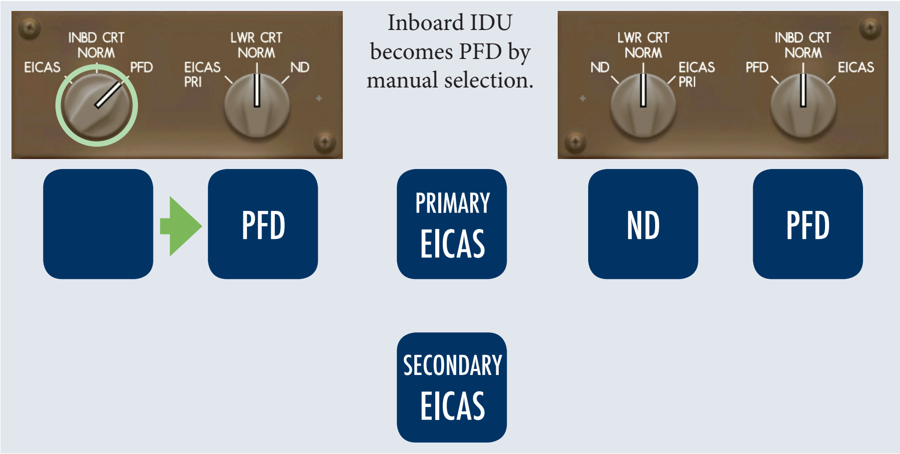
IDU Switching: *(continued)*



Inboard IDU becomes PFD automatically when outboard IDU fails.



Inboard IDU becomes PFD by manual selection.

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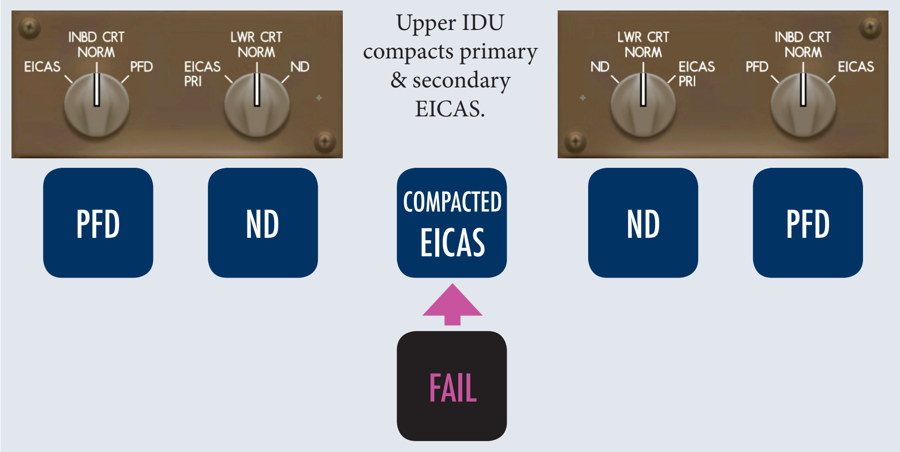
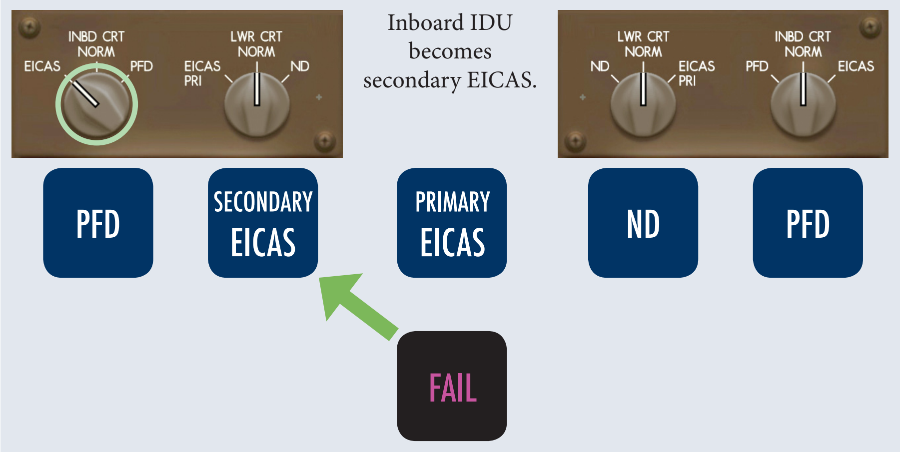
IDU Switching: *(continued)*



Upper IDU compacts primary & secondary EICAS.



Inboard IDU becomes secondary EICAS.

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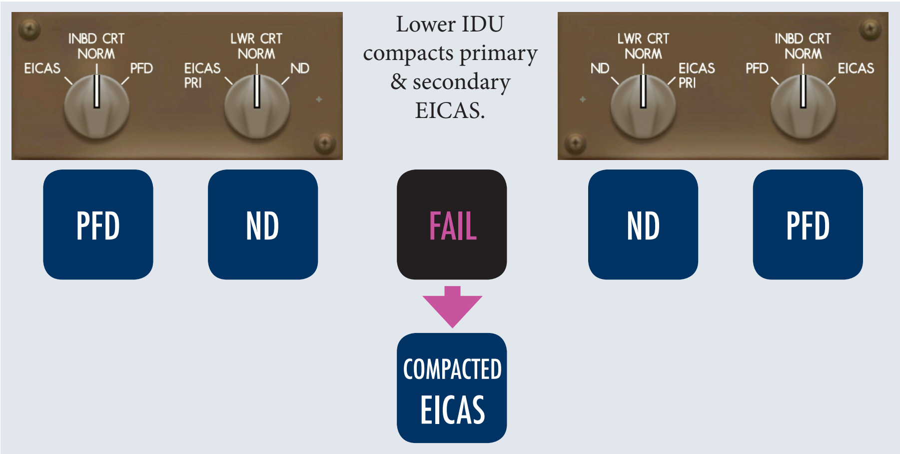
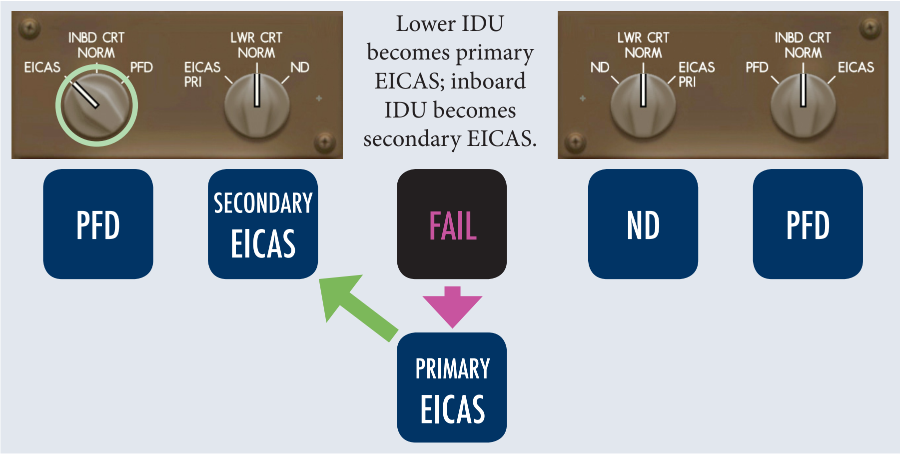
IDU Switching: *(continued)*





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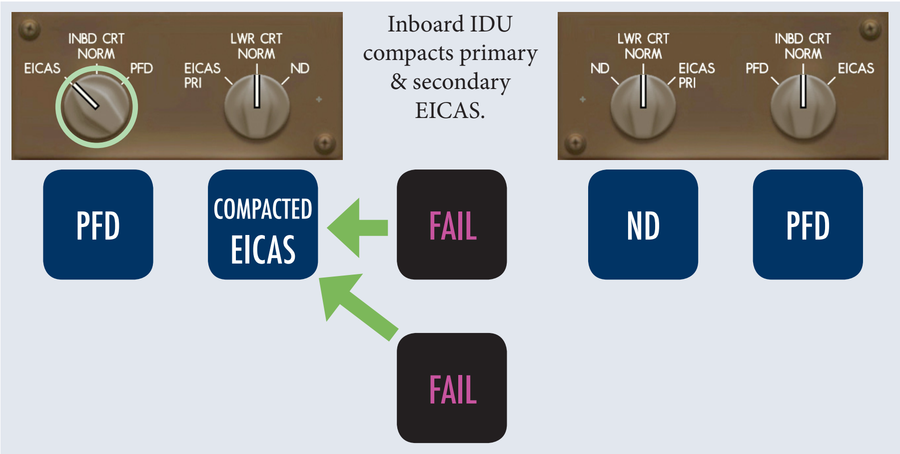
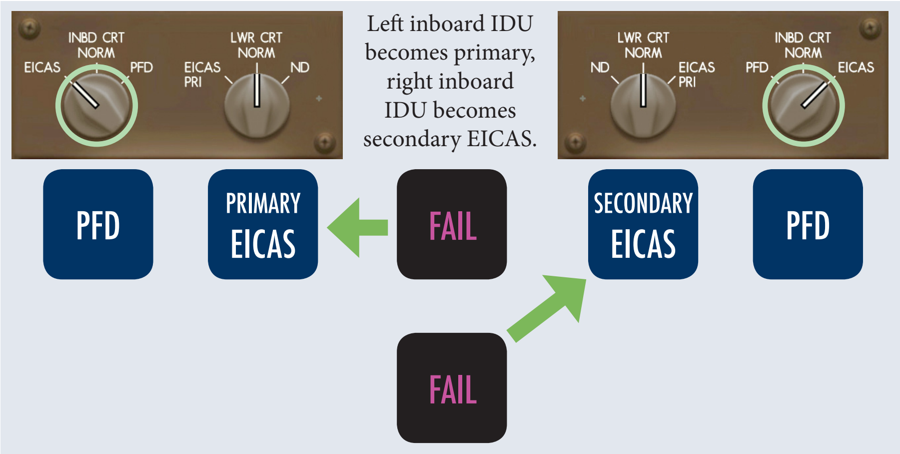
IDU Switching: *(continued)*



Inboard IDU compacts primary & secondary EICAS.



Left inboard IDU becomes primary, right inboard IDU becomes secondary EICAS.

Instrument Sources:

The IDS is interfaced with three **EFIS/EICAS interface units (EIUs)**. Each of the three EIUs receives the same data from a multitude of aircraft systems, and sends these data to selected IDUs.

Weather radar and **terrain** images are not routed through the EIUs but are sent directly to the IDUs. Data from **navigation radios** such as VOR, DME, ADF, ILS, and markers are routed to the IDUs via the EIUs. For more information refer to chapter **Navigation Systems**.

Three **air data computers (ADCs)** process inputs from various pitot-static probes, temperature probes, and AOA sensors. ADCs provide airspeeds, barometric altitudes, altitude rates, and other air data.

The **inertial reference system (IRS)** comprises three **inertial reference units (IRUs).** Each IRU contains laser gyros and accelerometers to determine aircraft position, attitude, velocities and many other parameters. For more information refer to chapter **Navigation Systems** and chapter **FMS**. For the computation of the vertical speed, each IRU uses its internal velocity detection for short-term updates, and the barometric altitude rate (air data) for long-term updates. To get the barometric altitude rate, each IRU is linked with a certain ADC. The linked ADC supplies the IRU also with TAS data which the IRU applies in its wind calculation.

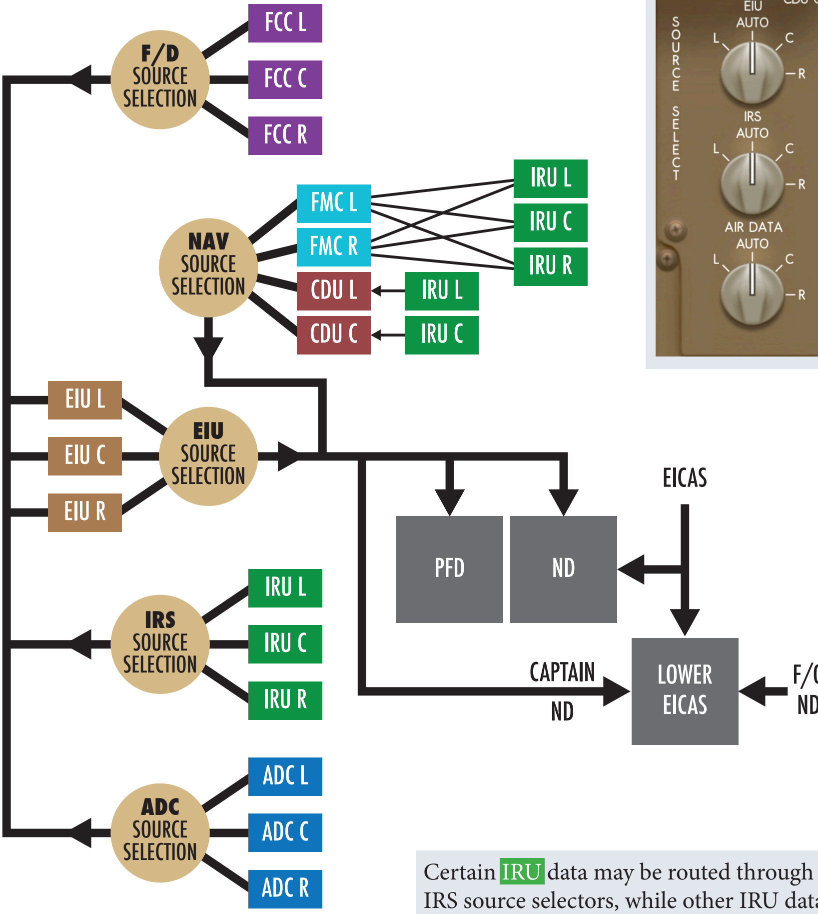
Two **flight management computers (FMCs)** provide routes, map data, aircraft position, heading, drift angle, ground speed, wind data and many other features for display on the IDUs. The FMCs receive and process data from IRUs, GPS units, navigation radios, and other systems. For more information refer to chapter **FMS**.

There are three **control display units (CDUs)** on the flight deck. Each CDU contains a copy of all non-conditional waypoints that have been entered in the FMS route; this means, in case of a dual FMC failure, each CDU can be used for simplified standby navigation. Each CDU receives aircraft position, heading, ground speed and other data from an associated IRU. IRU errors are not corrected: each selected CDU source may provide different position data. For more information refer to chapter **FMS**.

The **flight control computers (FCCs)** control the movement of the flight director crossbars or V-bars on the PFDs. The FCCs are part of the autopilot & flight director system; for more information refer to chapter **Automatic Flight**.

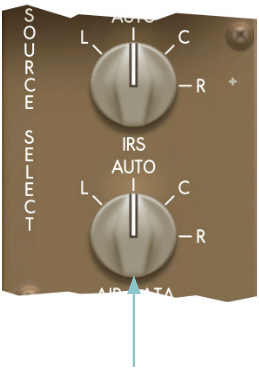
Instrument Source Selection:

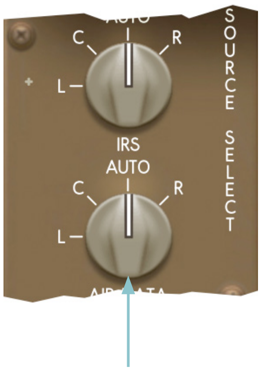
Selection principle in the captain's system
(The first officer's system is similar except for the linked pair CDU L – IRU L being replaced by the linked pair CDU R – IRU R in the NAV sources.)



Certain IRU data may be routed through IRS source selectors, while other IRU data are routed through FMCs. For more details refer to the next page.

Instrument Source Selection:





Captain's IRS source selector
The selected IRU (L, C, or R) provides attitude and vertical speed data to the captain's PFD. The captain's selected IRU also feeds the autobrake system, the stall warning system, and the weather radar attitude system. The captain's heading, track, wind, slip, skid, flight path angle, and ground speed data are normally provided via FMC L which receives data from all IRUs. For the captain's data supply, FMC L uses IRU L if IRU L is operative, else IRU C if that is operative, else IRU R. The changeover is automatic. If FMC L fails, the captain's PFD and ND receive all data from the one IRU that is set by the captain's IRS source selector.

A **AUTO** If FMC L fails, selects IRU L if it is operative, else IRU C if that is operative, else IRU R.

First officer's IRS source selector
The selected IRU (R, C, or L) provides attitude and vertical speed data to the first officer's PFD. It also feeds the weather radar attitude system. Heading, track, wind, slip, skid, flight path angle, and ground speed data are normally provided via FMC R which receives data from all IRUs. For the first officer's data supply, FMC R uses IRU R if IRU R is operative, else IRU C if that is operative, else IRU L. The changeover is automatic. If FMC R fails, the first officer's PFD and ND receive all data from the one IRU that is set by the first officer's IRS source selector.

A **AUTO** If FMC R fails, selects IRU R if it is operative, else IRU C if that is operative, else IRU L.

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Instrument Source Selection: *(continued)*

Captain's panel

Flight director source selector
The selected FCC controls the movement of the flight director on the respective pilot's PFD.

Navigation source selector
The selected FMC provides data to the respective pilot's PFD and ND. The selected CDU provides standby navigation data to the respective pilot's ND.

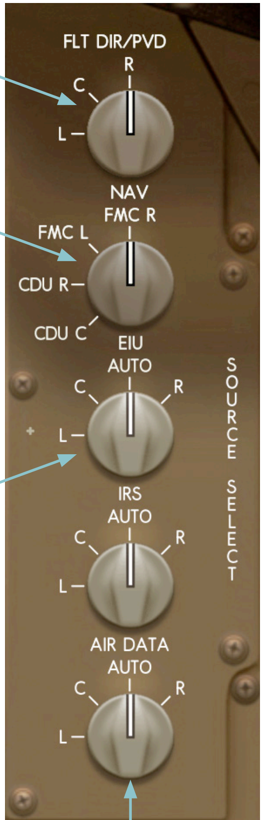
EIU selector
The selected EIU provides the interface between the respective pilot's IDUs and the selected instrument sources (FCC, IRS, ADC, among others).

AUTO

For captain:
Selects EIU L if it is operative, else EIU C if that is operative, else EIU R.

For first officer:
Selects EIU R if it is operative, else EIU C if that is operative, else EIU L.

First officer's panel



Captain's ADC source selector
Selected ADC provides air data to captain's PFD and IRU L. Air data selection for IRU C is controlled by stepper relay logic (pilot selections exclude each other).

A **AUTO** Selects ADC L if it is operative, else ADC C if that is operative, else ADC R.

First officer's ADC source selector
Selected ADC provides air data to first officer's PFD and IRU R. Air data selection for IRU C is controlled by stepper relay logic (pilot selections exclude each other).

A **AUTO** Selects ADC R if it is operative, else ADC C if that is operative, else ADC L.

A ADC C is optionally installed.

Pitot-Static Sources:

The forward fuselage is fitted with four pitot-static probes (upper left & right; lower left & right) and a pair of alternate static pressure ports. An additional pair of static pressure ports are installed on the aft fuselage. The probes and ports feed the following systems:

A If **two** ADCs are installed:

UPR L pitot (captain):	ADC L
UPR R pitot (first officer):	ADC R
LWR L pitot (auxiliary 1):	Elevator feel; standby airspeed
LWR R pitot (auxiliary 2):	Elevator feel
UPR L & LWR R static (captain):	ADC L
UPR R & LWR L static (first officer):	ADC R
Alternate L & R static:	Standby airspeed & altimeter
Aft fuselage L & R static:	Elevator feel

A If **three** ADCs are installed:

UPR L pitot (captain):	ADC L
UPR R pitot (first officer):	ADC R; first officer's ADC C selection
LWR L pitot (auxiliary 1):	Elevator feel; standby airspeed
LWR R pitot (auxiliary 2):	Elevator feel; captain's ADC C selection
UPR L & LWR R static (captain):	ADC L
UPR R & LWR L static (first officer):	ADC R
UPR L & LWR R static (auxiliary 1):	Captain's ADC C selection
UPR R & LWR L static (auxiliary 2):	First officer's ADC C selection
Alternate L & R static:	Standby airspeed & altimeter
Aft fuselage L & R static:	Elevator feel

For details on the elevator feel system refer to chapter **Flight Controls**.

EFIS Control Panel:

There is a left and a right EFIS control panel. Each panel controls the onside PFD and ND. The left or right CDU may also be enabled to provide EFIS control; when enabled, the onside EFIS control panel is deactivated.

Radio/barometric selector (outer knob)

RADIO Enables the minimums selector to set a *radio altitude* reference on the PFD.

BARO Enables the minimums selector to set a *barometric altitude* reference on the PFD.

Meters switch

Push Shows or blanks the metric altitude indications.

Inch/hectopascal selector (outer knob)

IN Enables the barometric selector to set a pressure reference in *inches of mercury*.

HPA Enables the barometric selector to set a pressure reference in *hectopascals*.

Minimums selector (inner knob)

Rotate Sets a radio or barometric altitude reference on the PFD.

A Barometric selection is in 1 or 10 ft steps as per option setting.

Barometric selector (inner knob)

Rotate Sets a pressure reference for the barometric altimeter on the PFD.

Standard switch

Push If STD is displayed on the PFD, applies the selected pressure; else overrides the selected pressure and applies 29.92 in./ 1013.25 hpa.

Reset switch

Push Resets the flashing amber radio altitude reference on the PFD.

Flight path vector switch

Push Shows or blanks the flight path vector on the attitude indicator.

(continued next page)

EFIS Control Panel: *(continued)*

ND mode selector

APP Shows information regarding the left or right ILS receiver (left receiver on the captain‘s ND, right one on the first officer‘s), including DME readout if paired, and associated course and glideslope deviation indicators. Compass rose refers to heading.

VOR Shows information regarding the left or right VOR receiver (left receiver on the captain‘s ND, right one on the first officer‘s), including DME readout if paired, and associated course deviation indicator. Compass rose refers to heading.

MAP Shows route and map data of the selected onside navigation source (FMC L, FMC R, or a CDU).

A Compass rose refers to heading or track, as specified by the airline.

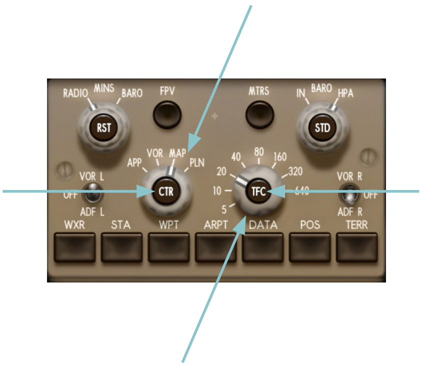
PLN Shows route in true north up orientation.

A Compass rose refers to heading or track, as specified by the airline.

A Blanks the compass rose on LCD type IDUs.

Center switch

Push Alternately changes between an expanded and a smaller, centered compass rose display if the ND is not in PLN mode.



Traffic switch

Push Shows or blanks TCAS targets on the ND. TCAS targets can appear when ND is in MAP mode, or when in expanded APP or VOR mode.

ND range selector

5 to 640 Sets the map range in nautical miles between the aircraft symbol and the upper compass rose edge if the compass rose is expanded, otherwise sets the map range between the upper and lower compass rose edges.—The route display from CDU C is scaled by the left EFIS control only.

(continued next page)

EFIS Control Panel: *(continued)*

VOR/ADF switch (L, R)

VOR Shows bearing pointer and data of respective VOR.

OFF Removes pointer and data.

ADF Shows bearing pointer and data of respective ADF.

A Switch directions may be reversed (VOR down, ADF up).

Map switch

First push shows specific information on the ND, second push blanks the respective information. All functions, except for WXR and TERR, require the onside NAV source selector to be set to FMC L or FMC R.

WXR and TERR images range to 320 nm only. WXR and TERR information cannot be shown simultaneously on one ND. WXR information may appear automatically when a windshear is predicted. TERR information may appear automatically when a collision is predicted. WXR has priority.

WXR Powers the weather radar antenna and shows radar images on the ND when the ND is in MAP mode, or when in expanded APP or VOR mode. Blanks TERR information.

STA Shows VOR and DME facilities when ND is in MAP mode. Low altitude navigation aids are shown when ND range is set below 80; high altitude navigation aids are shown in all ND ranges.

A No stations are shown when ND range is 640.

WPT Shows waypoints when MAP mode is selected and ND range is set below 80.

ARPT Shows airports when MAP mode is selected.

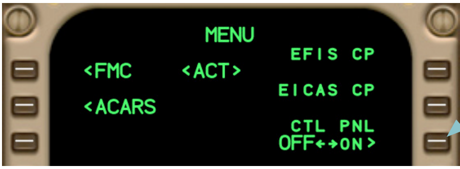
A No airports are shown when ND range is 640.

DATA Shows, if applicable, each route waypoint's estimated time of arrival (ETA) and altitude constraint when MAP or PLN mode is selected. When DATA is not selected, only the next constraint's ETA and altitude are shown.

POS Shows information to check the position accuracy of the tuned navaids, the IRS, and GPS. Applicable when MAP mode is selected.

TERR Shows terrain image and numerical data on the ND when ND is in MAP mode, or when in expanded APP or VOR mode. Blanks WXR information.

Alternate EFIS Control:



Control panel key
Located on the MENU page of CDU L & R. Enables the onside CDU to control the onside PFD and ND. Deactivates the onside EFIS control panel.

EFIS control panel key
Opens the EFIS CONTROL page.

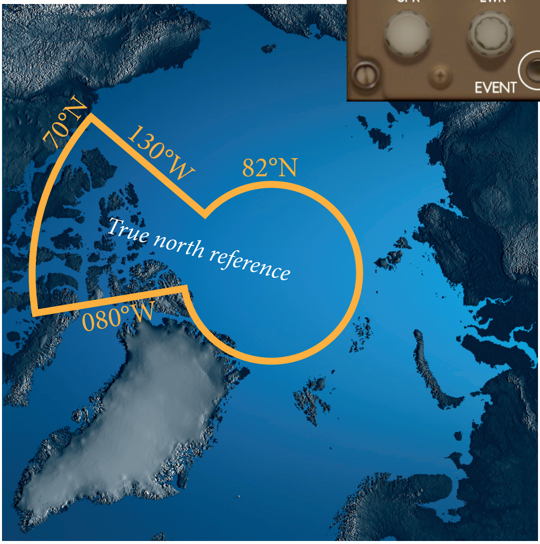
EFIS CONTROL page and EFIS OPTIONS page
The functions are identical to the switch and selector functions of the EFIS control panel, except for the features described below:

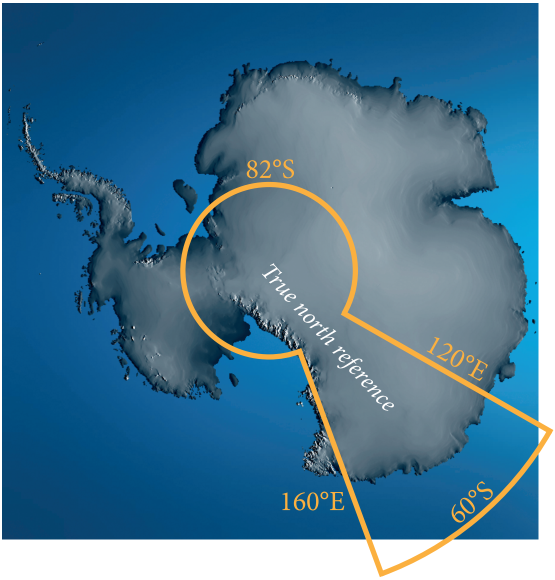
Barometric setting key
Valid entries are 745 through 1084, and 2200 through 3200, or 22.00 through 32.00 (the decimal may be omitted). Inches or hectopascals are applied automatically; the units can be changed also by entering the single letter I or H. The letter S sets STD.

Minimums setting key
Valid entries are -101 through 15000 for barometric, and -1 through 999 for radio minimums. The barometric minimum marker blanks at -101, the radio minimum marker blanks at -1.

ADF/VOR key
Blanks both sides, or shows ADF L & R, or VOR L & R.

Heading Reference:





Heading reference switch

TRUE Heading and track reference is true north for CDUs (active leg), FMS, PFDs, NDs, and AFDS. Grid north indicators on the NDs are removed.

NORM Heading and track reference in *FMS* and *active CDU leg* is magnetic north for locations between 73°N and 60°S, otherwise true north.

Heading and track reference for *PFDs, NDs,* and *AFDS* is magnetic north when the aircraft is outside the orange areas shown on the figures to the left; inside these areas it is true north.

The reference will change automatically.

When the aircraft is north of 73°N, or south of 60°S, grid north indicators appear on the NDs.

When the reference changes automatically or manually while HDG SEL is engaged, HDG HOLD will engage.

Airspeed Indication:

Airspeeds on this indication refer to CAS in knots.

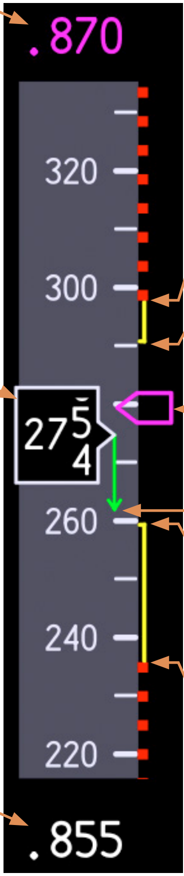
Command speed
Indicates airspeed selected on MCP when MCP airspeed window is not blank, otherwise the FMC selected airspeed.

Current airspeed
Indicates current airspeed computed by the selected onside ADC. Displays 30 when below 30 kt.

A White frame changes to amber when the current airspeed is below the minimum maneuvering speed.

Current Mach
Indicates current Mach computed by the selected onside ADC when at or above Mach 0.4. Boxed when first displayed.

A Indicates FMC computed groundspeed when below Mach 0.4. Boxed when first displayed.



Maximum speed
Indicates VMO, or gear placard speed, or flap placard speed, whichever is the lowest.

Maximum maneuvering speed
Indicates maneuver margin to flaps up buffet.

Command speed bug
Indicates airspeed selected on MCP when MCP airspeed window is not blank, otherwise the FMC selected airspeed. Bug edges equate to 2.5 kt deviation.

Airspeed trend vector
Indicates predicted airspeed in 10 seconds.

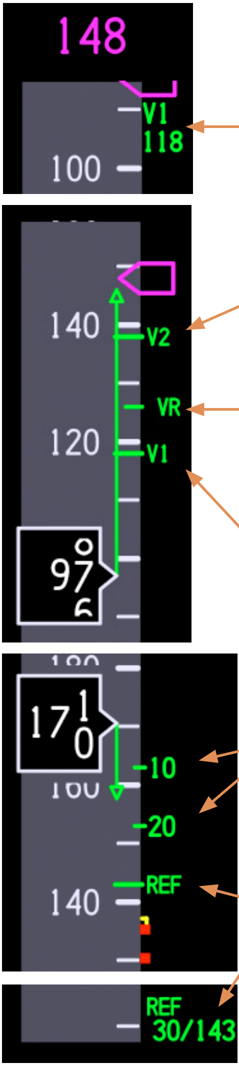
Minimum maneuvering speed
Indicates maneuver margin to low speed buffet or to stick shaker speed.

Minimum speed
Indicates low speed buffet and stick shaker speed.

(continued next page)

Airspeed Indication: *(continued)*

For V speed entries in the FMC refer to chapter **FMS**.



V1 numerical indication
Indicated at the top when V1 is off the scale.

V2 speed
Indicated during takeoff before initial flap retraction and when selected in the FMC.

VR speed
Indicated during takeoff roll and when selected in the FMC. When difference to V1 is less than 4 knots, “VR” is replaced by “R”.

V1 speed
Indicated during takeoff roll and when selected in the FMC.

Flap speed
Indicated in flight after initial flap retraction and when below 20000 ft. Indicates speed for current flap setting and speed for next retracted flap.

Landing reference speed
Indicated when set in the FMC. Displayed at the bottom when off the scale.

Numerical indication and related landing flaps are always shown at the bottom when set in the FMC.

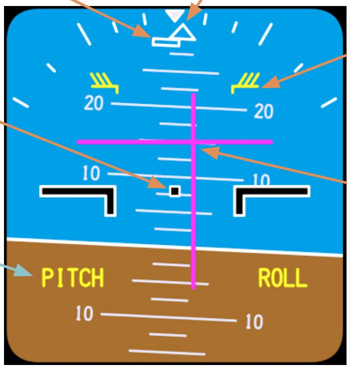
Attitude Indication:

Slip & skid indicator
Indicates IRU computed slip & skid.
A On LCD version, indicator changes to amber when slip or bank is excessive.

Bank pointer & scale
Indicates bank computed by onside selected IRU. Scale marks are at 0°, 10°, 20°, 30°, 45°; A on LCD version also at 60°, and with amber pointer when bank is excessive.

Pitch indicator
Indicates pitch computed by onside selected IRU.

Pitch & roll disagree flags
Displayed when a disagreement is detected between the captain's and first officer's attitude indications.



A **Crossbar** type attitude indicator

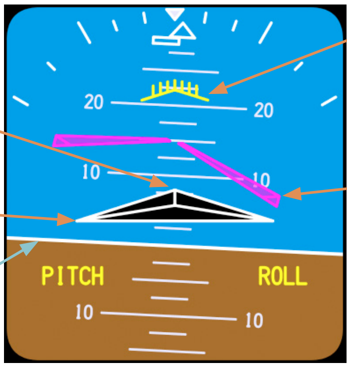
Pitch limit indicator
Indicates pitch limit where stick shaker will activate. Removed when flaps are up.

Flight director crossbars
Indicate flight director pitch and bank commands. For more information refer to chapter **Automatic Flight**.

Pitch indicator
Indicates pitch computed by onside selected IRU.

Aircraft symbol
Symbolizes aircraft roll attitude relative to horizon line.

Horizon line



A **V-bar** type attitude indicator

Pitch limit indicator
Indicates pitch limit where stick shaker will activate. Removed when flaps are up.

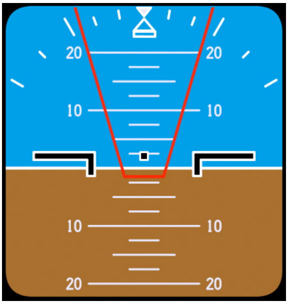
Flight director V-bar
Indicates flight director pitch and bank commands. For more information refer to chapter **Automatic Flight**.

To enhance situational awareness, a fraction of the blue or brown area remains in view at the edge until the actual pitch exceeds +85° or -85°.

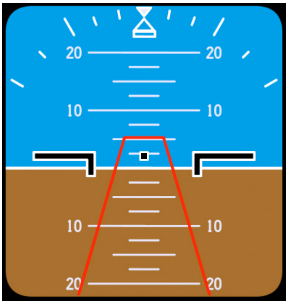
(continued next page)

Attitude Indication: *(continued)*

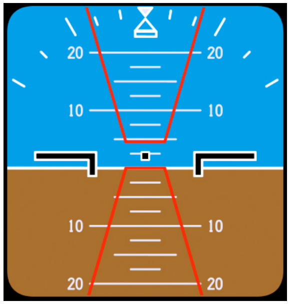
TCAS RA pitch commands
Indicated during a TCAS resolution advisory (RA); for operation details refer to chapter **Warning Systems**. The pilot is supposed to move the aircraft pitch indicator off the red-outlined zone.



Descent command



Climb command



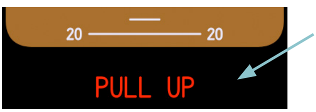
Monitor vertical speed

EGPWS pitch commands
Indicated during a ground proximity alert; for operation details refer to chapter **Warning Systems**.

A

Reactive windshear alert system detects *positive* windshear (sudden increase in headwind), typically encountered when flying into a microburst; expect negative windshear when leaving the microburst.

Reactive windshear warning system detects *negative* windshear (sudden increase in tailwind, or downwash).



EGPWS predicts collision with terrain.

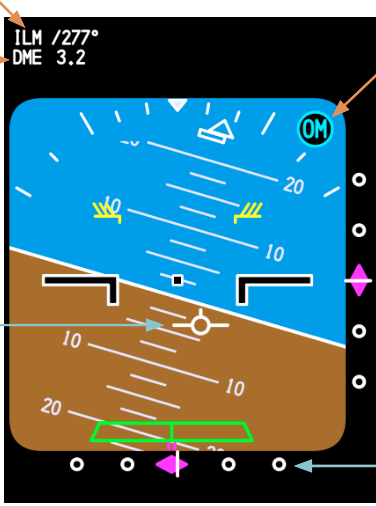
(continued next page)

Attitude Indication: *(continued)*

Approach reference
Indicates tuned ILS frequency, or—when decoded—station identifier.
A On LCD version, also indicates approach course.

DME indicator
Indicates DME if paired with tuned ILS, otherwise displays dashes.

Flight path vector (FPV)
Indicates horizontal drift angle relative to pitch scale center, and vertical flight path angle relative to horizon. Removed when rising runway is above its parked position.



A **LCD** type PFD

Marker beacon

IM Inner marker or airway marker.

MM Middle marker.

OM Outer marker.

Glideslope indicator
Magenta diamond is removed when on backcourse.

Localizer indicator
Scale consists of four dots when in manual flight; scale expands to a more precise display during autoland when the aircraft is close to the centerline.

FPV on CRT version includes moving arms that stay parallel to the horizon.

A **Rising runway**
Active in flight below 200 ft radio altitude when an ILS is tuned.

Approach course indication on CRT version.

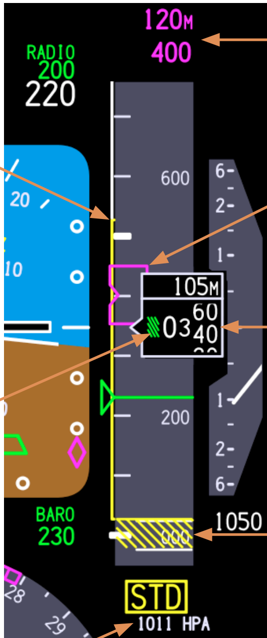
A **CRT** type PFD

Glideslope & localizer indicators blank when ILS is parked or when bank angle is excessive. Diamonds are removed when no signals are received. If deviation is excessive at low altitude, with AFDS engaged, respective scale turns amber and diamond flashes.

Altitude Indication:

- Selected and current altitudes are paired with another display indicating the respective altitude in meters when MTRS is selected on EFIS control.
- Selected and current altitude indicators are boxed under certain altitude alert conditions. Refer to **Altitude Alert** in chapter **Automatic Flight**.

A **Landing altitude reference bar**
Amber bar extends from 0 to 500 ft above landing altitude; white bar extends from 500 to 1000 ft.



Selected altitude
Indicates altitude selected on MCP.

Selected altitude bug
Indicates altitude selected on MCP. Bug edges equate to 50 ft deviation.

Current altitude
Indicates barometric altitude computed by onside selected ADC.

Below 10000 mark
Green hatch appears when below 10000 ft; replaced by minus sign when altitude is negative.

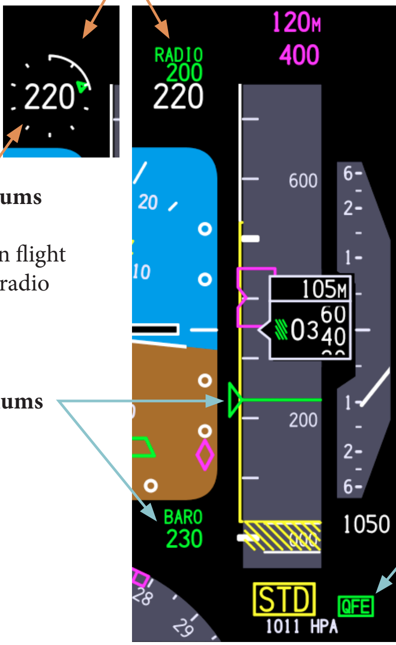
Touchdown zone
Upper edge of amber hatch indicates the landing altitude provided by the FMS.

Barometric altimeter setting
Indicates the setting of the onside EFIS control. When the barometric selector is rotated while STD is displayed, the set value appears as a preselection in small white font; it activates and turns to large green font when the STD switch is pushed. During departure, the setting turns amber when the aircraft is 300 ft above the transition altitude. During arrival, STD turns amber when the aircraft is 300 ft below the transition level.

(continued next page)

Altitude Indication: *(continued)*

Radio minimums
Indication is amber during approach when the aircraft is at or below minimum, and above zero. Flashes for 5 seconds when descending through minimum.



A **Radio minimums with dial**
Dial appears in flight below 1000 ft radio altitude.

Barometric minimums

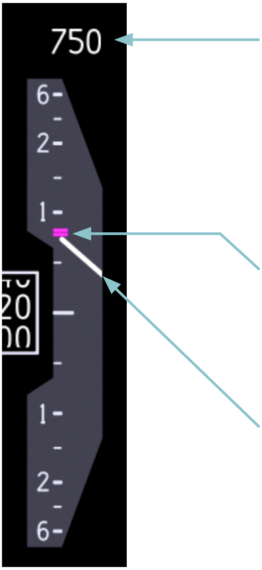
A Depending on airline specifications, the radio altitude is displayed either inside the attitude indicator or above it. If it is above it, the numerical *radio* minimums are placed above the attitude indicator, and the numerical *barometric* minimums below the attitude indicator,—otherwise the layout is reversed.

A **QFE flag**
When QFE is selected on FMC APPROACH REF page, touchdown zone is set to 0 ft and QFE flag is continuously displayed. When QNH is selected (normal mode), QNH flag is displayed for 10 seconds.

Flight Mode Annunciation:

Refer to chapter **Automatic Flight**.

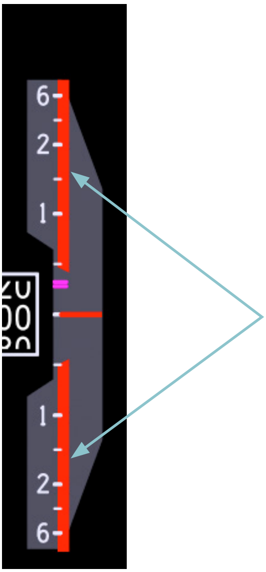
Vertical Speed Indication:



Numerical indication
Indicates current vertical speed in feet per minute, computed by onside selected IRU. Displayed at the top when climbing; or at the bottom when descending; or blanks when climb or descent rate is less than 400 fpm. Indicates 9999 when rate exceeds 9999 fpm.

Selected vertical speed
Indicates vertical speed selected on MCP. Removed when MCP V/S window is blank.

Vertical speed pointer & scale
Indicates current vertical speed. Scale marks are at 500, 1000, 1500, 2000, 4000, and 6000.



A **TCAS RA commands**
Indicated during a TCAS resolution advisory (RA); for operation details refer to chapter **Warning Systems**. The pilot is supposed to maintain a vertical speed outside the red zone.

Heading Indication:

Heading pointer
Indicates heading computed by selected onside FMC or, if FMC data are invalid, by onside selected IRU.

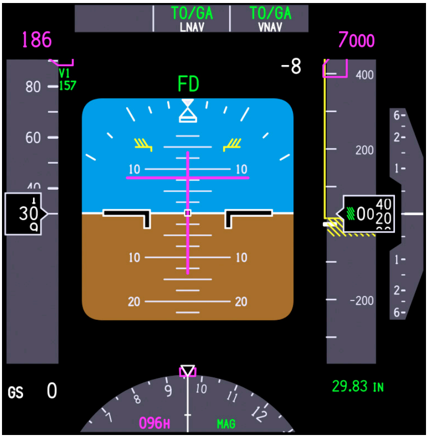
Track indicator
Indicates track computed by selected onside FMC or, if FMC data are invalid, by onside selected IRU.

Selected heading
Indicates heading selected on MCP.

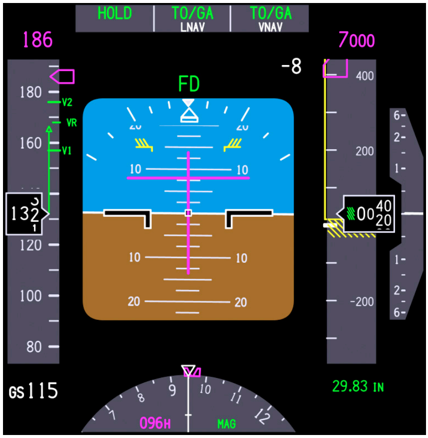
A On LCD type IDU, an “H” is attached to the numerical indication.

Heading reference
Displays MAG or TRU to indicate current north reference for heading and track. When changing to MAG, a green box is displayed for 10 seconds. When TRU is the reference, a white box is displayed continuously, and the box turns amber and flashes for 10 seconds when the aircraft has descended by 2000 ft at 800 fpm or more; it resets to white when climbing by 2000 ft at 500 fpm or more.

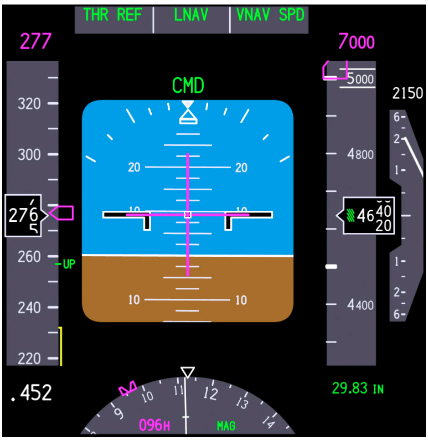
Typical PFD Indications:



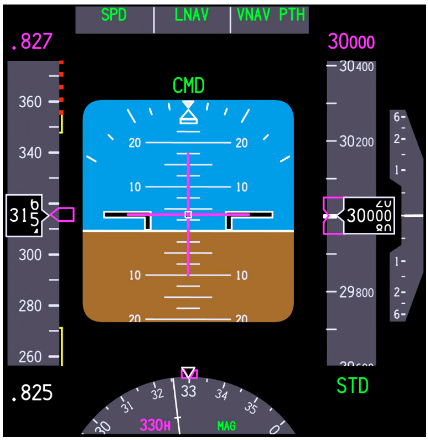
Preflight



Takeoff



Climb

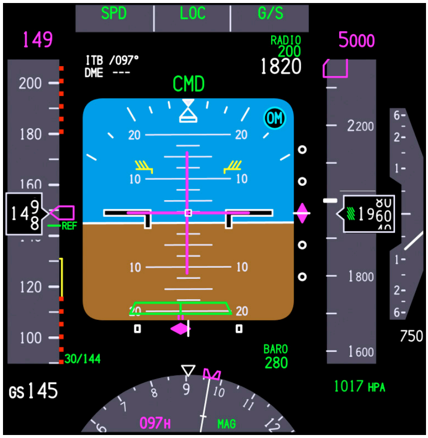


Cruise

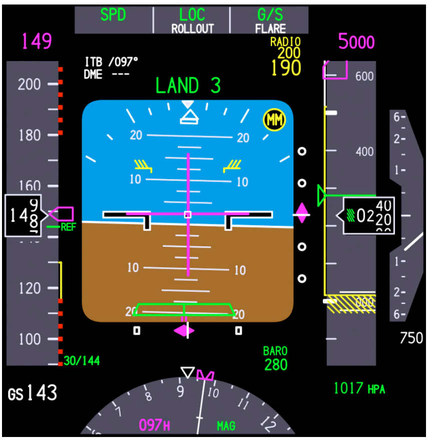
(continued next page)

Typical PFD Indications: *(continued)*

Descent



Approach

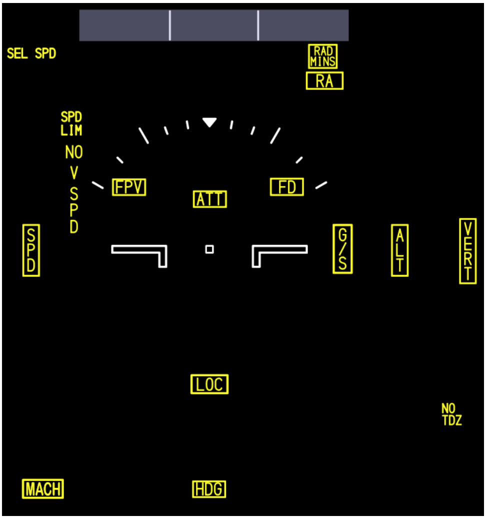


Landing

Rollout

A Flight director commands are removed from attitude indicator when ROLLOUT is engaged.

PFD Failure Flags:



SPD
Invalid airspeed data; for example, due to ADC failure.

MACH
Invalid Mach data. Inhibited by SPD flag. *(The simulator does not model Mach invalidation while airspeed is valid.)*

SEL SPD
Invalid MCP selected speed; for example, due to failure of all three FCCs. Inhibited by SPD flag.

SPD LIM
Invalid airspeed limits data; for example, because of dual MAWEA failure or dual FMC failure. Inhibited by SPD flag.

NO V SPD
No valid V1, VR, and V2 speeds received from FMC. Inhibited by SPD flag.

FPV
Invalid flight path vector data while IRU is operative; for example, when FPV is activated during IRU alignment.

ATT
Invalid IRU attitude data; for example, due to IRU failure.

FD
Invalid flight director data; for example, due to FCC failure.

RAD MINS
Invalid radio minimums data; for example, due to failure of onside CDU and onside EFIS control panel.

RA
Invalid radio altitude data; for example, due to failure of all three radio altimeters.

LOC & G/S
Invalid ILS data; for example, due to failure of all three ILS receivers.

HDG
Invalid heading data; for example, due to failure of all three IRUs.

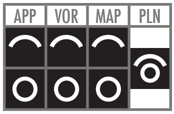
ALT
Invalid barometric altitude data; for example, due to ADC failure, or due to altitude indication being above 50000 or below -2000 ft.

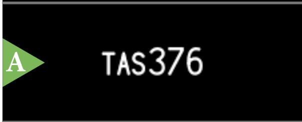
VERT
Invalid vertical speed data; for example, due to IRU failure.

NO TDZ
No valid touchdown zone data; for example, due to missing airport entry in FMC, or due to FMC failure.

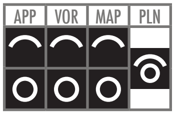
ND Symbology:

Ground speed
Digits are enlarged when below 30 kt.

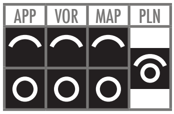


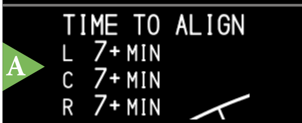


True airspeed
Blank when below 100 kt.

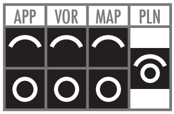


Wind direction & speed
Arrow direction is relative to heading. Display blanks when wind speed drops below 4 kt; redisplays when above 5 kt.

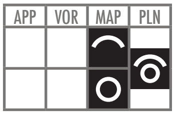




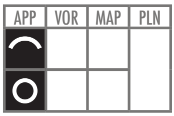
Time-to-align indication
Displayed during IRU L, C, or R alignment.



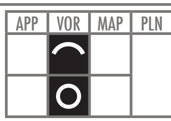
Grid heading
Displayed when aircraft is north of 73°N or south of 60°S, and heading reference switch is set to NORM.



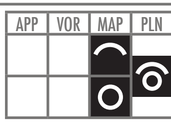
ILS reference data
Displays the onside tuned frequency or station identifier, the selected course, and—if paired—the DME distance.

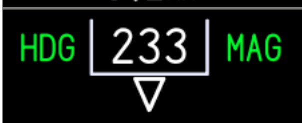


VOR reference data
Displays the onside tuned frequency or station identifier, the selected course, and—if paired—the DME distance.

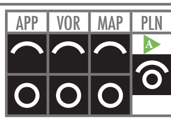


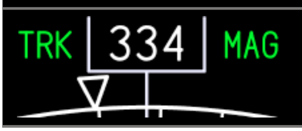
Active waypoint data
Displays the name, the estimated time of arrival (ETA), and the distance from the aircraft.



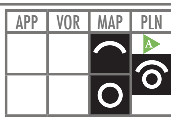


HDG flag (green) & pointer (white)
The compass vertical indicates aircraft heading, which refers either to MAG or TRU. Optional in MAP & PLN mode.





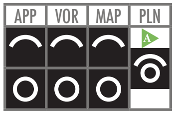
TRK flag & heading pointer (white)
The compass vertical indicates aircraft track, which refers either to MAG or TRU. Optional in MAP & PLN mode.

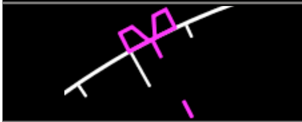


(continued next page)

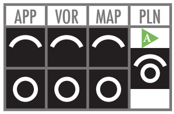
ND Symbology: *(continued)*

Compass north reference
Indicates either MAG or TRU (magnetic or true north). Green box is displayed for 10 seconds when switching to MAG.

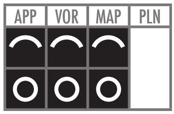


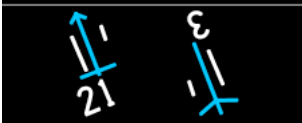


Selected MCP heading
If LNAV is engaged, dashed line blanks 10 seconds after every reselection.

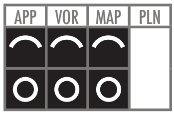


Bearing pointer of VOR L
Arrow tip on compass rose indicates bearing to VOR; arrow tail indicates bearing from VOR.

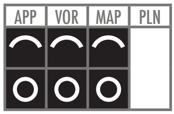




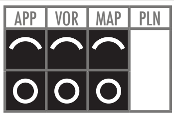
Bearing pointer of ADF L
Arrow tip on compass rose indicates bearing to NDB; arrow tail indicates bearing from NDB.



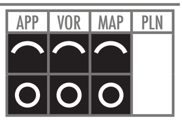
Bearing pointer of VOR R
Arrow tip on compass rose indicates bearing to VOR; arrow tail indicates bearing from VOR.

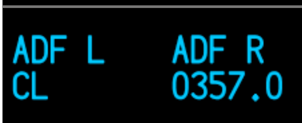


Bearing pointer of ADF R
Arrow tip on compass rose indicates bearing to NDB; arrow tail indicates bearing from NDB.

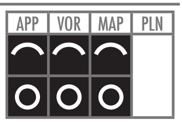


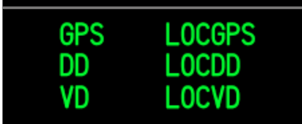
VOR information
Displays frequency, or station identifier when decoded; displayed in small font if station is a DME without VOR.



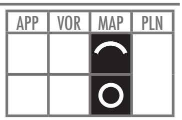


ADF information
Displays frequency, or station identifier when decoded.

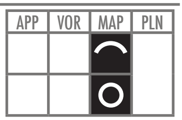




FMC radio update status
GPS is GPS only, DD is DME-DME, VD is VOR-DME, LOC is localizer.



IRS/FMC update status
FMC uses all three IRUs or—if an IRU fails—a single IRU. Display is boxed for 10 seconds when changing to single IRU.



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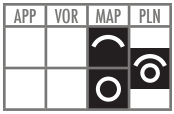
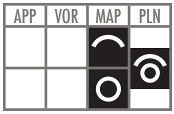
ND Symbology: *(continued)*

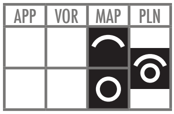
Runway with centerline
Selected origin or destination runway is displayed when ND range is set to 40 or below.

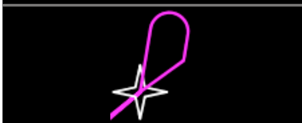


Simplified runway with airport code
Displayed when ND range is set above 40. Circle indicates which end of the line refers to the runway threshold.

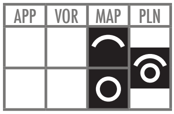


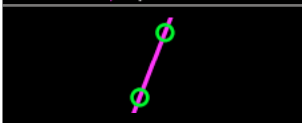
Holding pattern
Symbol size is fixed when the hold is not active or when the ND range is above 80.



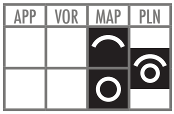


Procedure turn
Symbol size is fixed when the turn is not active or when the ND range is above 80.

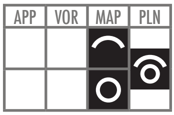




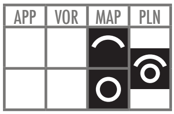
Deceleration segment
Unlabeled green circles indicate start and end of deceleration segment on arrival route.



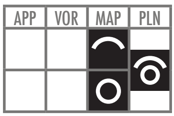
Altitude profile points
T/C is top of climb, S/C is step climb, T/D is top of descent, E/D is end of descent.

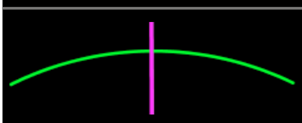


Time prediction point
Refers to entry on FMC FIX INFO page. Point is based on FMC predictions.

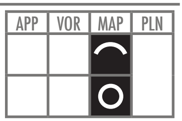


Altitude prediction point
Refers to entry on FMC FIX INFO page. Point is based on FMC computed climb or descent profile.

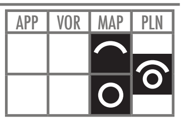




Altitude range arc
Indicates where the MCP altitude will be captured, based on current ground speed and current vertical speed.



Route waypoint & data
Shows respective altitude constraint or step altitude, and ETA. Active waypoint is displayed in magenta, others in white.



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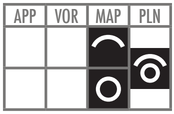
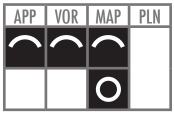
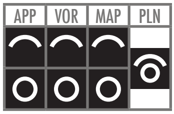
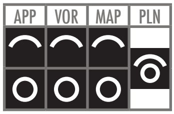
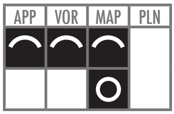
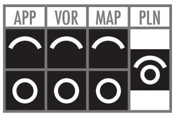
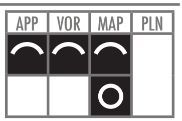
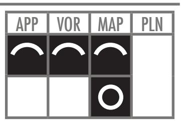
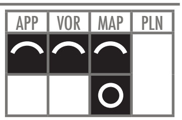
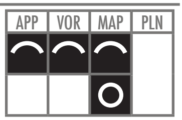
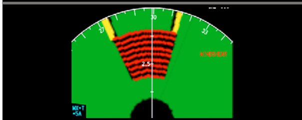
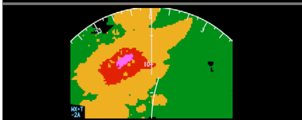
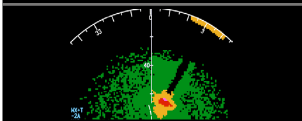
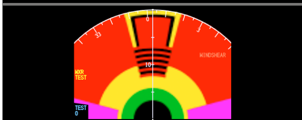
ND Symbology: *(continued)*

CDU L CDU C CDU R	**Map source annunciation** Displayed when the onside NAV source selector is set to a CDU.	
TFC	**TFC flag** Indicates that the ND is enabled to display traffic.	
TA ONLY	**TA ONLY flag** Indicates that TCAS resolution advisories are inhibited.	
TRAFFIC TRAFFIC	**TCAS TA (amber) or RA (red)** Annunciation in amber is a traffic advisory (TA), in red a resolution advisory (RA).	
OFFSCALE TRAFFIC	**TCAS TA or RA with offscale traffic** TCAS TA or RA refers to traffic located outside the ND range.	
TRAFFIC RA 8.5 -03 RA 8.5 +03	**TCAS TA or RA without bearing info** Lists traffic distances in nm, and relative or absolute altitudes in hundreds of feet.	
00 ■↓	**RA traffic (if TFC selected)** *For all traffic symbols: Arrow indicates trend if rate is greater than 500 fpm; digits show relative or absolute altitude.*	
●↑ -07	**TA traffic (if TFC selected)** *This example shows a relative altitude (two digits) of -700 ft.*	
◆↑ 406	**Proximate traffic (if TFC selected)** Traffic within 6 nm lateral and 1200 ft vertical. *This example shows an absolute altitude (three digits) of 40600 ft.*	
+17 ◇↑	**Other traffic (if TFC selected)** Traffic beyond 6 nm lateral or beyond 1200 ft vertical.	

(continued next page)

ND Symbology: *(continued)*

WINDSHEAR	**Predictive windshear caution** Weather radar system predicts a windshear near the aircraft flight path.	APP VOR MAP PLN
WINDSHEAR	**Predictive windshear warning** Weather radar system predicts a windshear ahead of the aircraft.	APP VOR MAP PLN
	**Predicted windshear zone** Red stripes indicate location of windshear. Amber radials indicate windshear sector on compass rose.	APP VOR MAP PLN
	**Weather radar returns** Red, amber, and green areas indicate intensity. Turbulence in magenta if in WX+T mode and ND range below 80.	APP VOR MAP PLN
	**Path attenuation alert bar** Amber arc on compass rose indicates sector of a radar shadow in which weather may not be shown.	APP VOR MAP PLN
	**Weather radar system test image** Displayed when TEST is selected or both TFR switches are pushed on weather radar control panel.	APP VOR MAP PLN
WXR WX+T MAP	**Weather radar display mode** WXR is the normal mode; WX+T also shows turbulence if ND range is below 80; MAP shows ground clutter only.	APP VOR MAP PLN
WXR -1M -G4 WXR +3M MAX	**Radar antenna tilt angle & gain** M-values are manual tilt settings, A-values are automatic tilt settings. G-values are manual gain settings.	APP VOR MAP PLN
TERRAIN TERRAIN	**EGPWS terrain alert** Terrain caution is amber, terrain warning is red.	APP VOR MAP PLN
TERR	**TERR flag** Indicates ND is enabled to show terrain.	APP VOR MAP PLN

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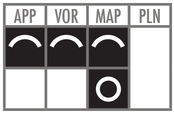
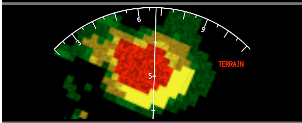
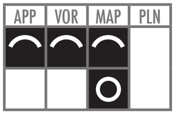
ND Symbology: *(continued)*

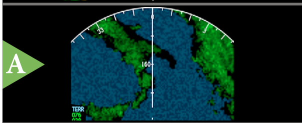
Peaks mode data
Indicates altitude of highest obstacle (upper value) and of lowest terrain (lower value) in displayed sector.



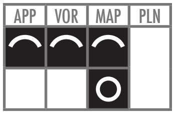


Terrain display
Tiles in different colors and dot patterns indicate certain relative altitudes. Refer to **EGPWS** in chapter **Warning Systems**.

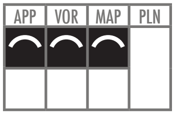




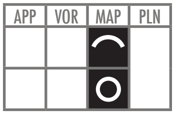
Sea level display (cyan)
Optionally enabled if peaks mode function is installed. Indicates sea area when land is within displayed sector.



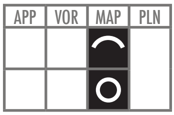
WXR and terrain range arcs
Three range arcs are shown in white.



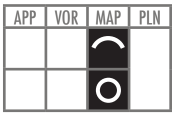
Airports
Shown when ARPT is selected on the onside EFIS control.

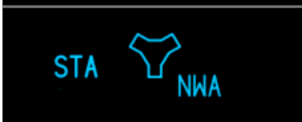


Waypoints
Shown when WPT is selected on the onside EFIS control and ND range is below 80.

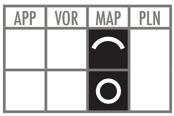


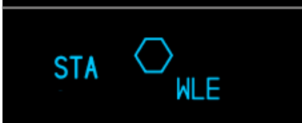
VORDME and VORTAC stations
Shown when STA is selected on the onside EFIS control.



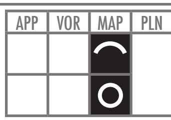


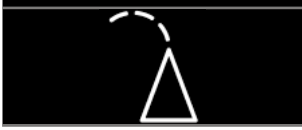
DME stations
Shown when STA is selected on the onside EFIS control.



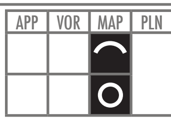


VOR-only stations (no paired DME)
Shown when STA is selected on the onside EFIS control.

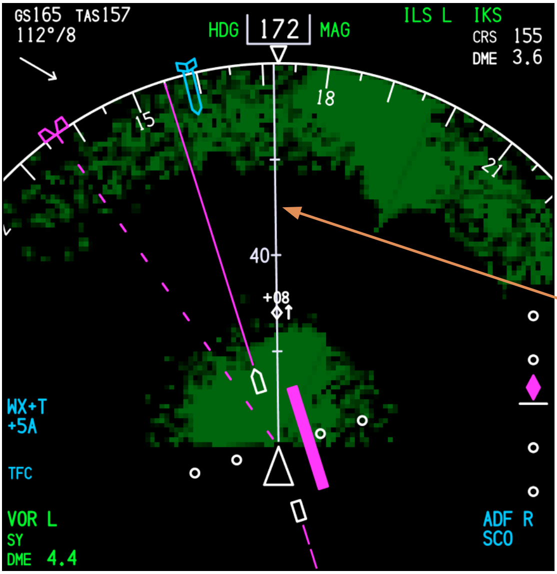




Aircraft triangle & trend vector
Trend indicates lateral path based on bank angle and ground speed. Each segment equates to 30 seconds.



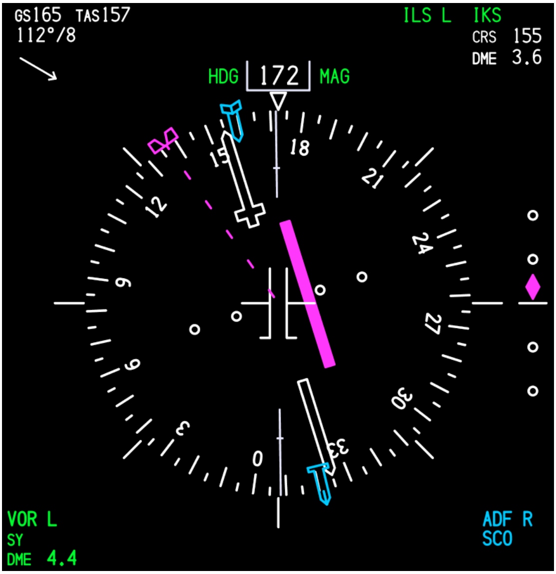
ND Approach Mode – Range Marks – Track Line:



In approach mode, the ND shows a **glideslope deviation indicator** and a localizer **course deviation indicator (CDI)** referring to the ILS course entered on the FMC NAV RADIO page. The magenta deviation bar is filled when it is 2.3 dots from the center.

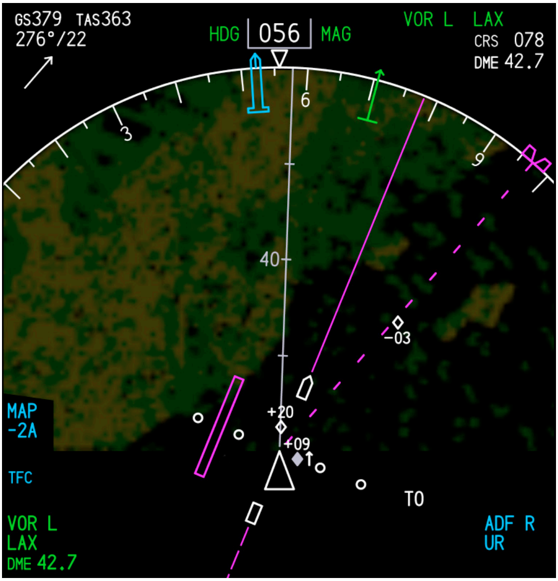
Track line & range marks

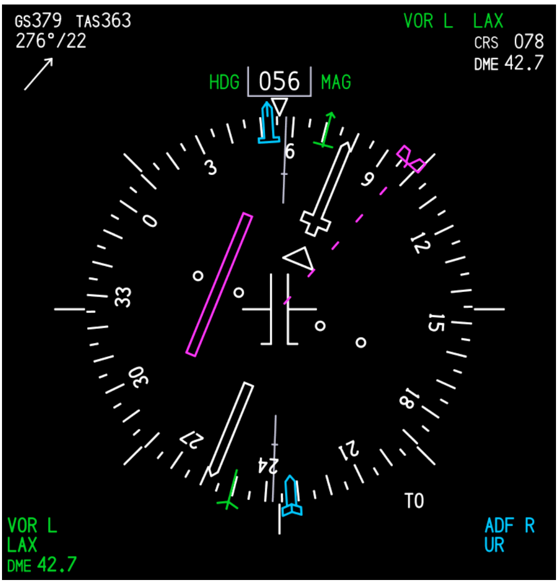
The track line is displayed in all ND modes except for the plan mode. When the ND range is changed, the system revalidates the scales of the FMC inputs and of the WXR or terrain inputs for a fraction of a second: during this process the range indication is blank.



A Optionally, in approach mode, the track line is replaced by a **triangle-shaped** track pointer.

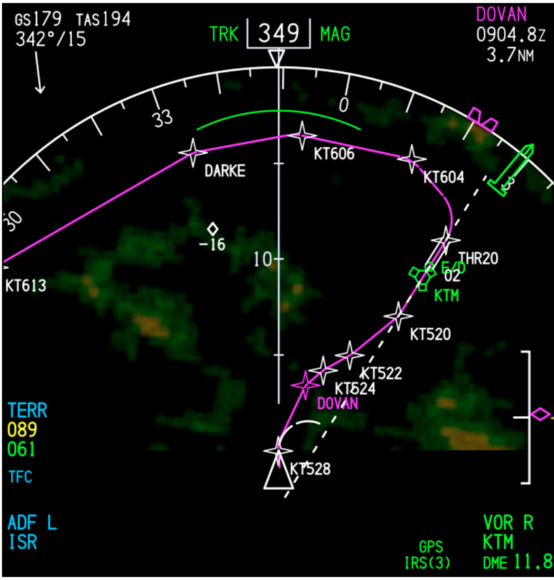
ND VOR Mode:





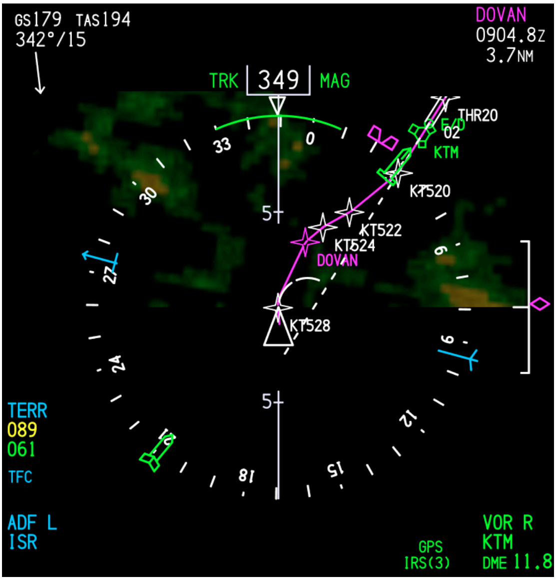
In VOR mode, the ND shows **TO** and **FROM** flags, and a **course deviation indicator (CDI)** referring to the respective course entered on the FMC NAV RADIO page. The magenta deviation bar is never filled; this distinguishes the VOR CDI from the localizer CDI.

ND Map Mode:

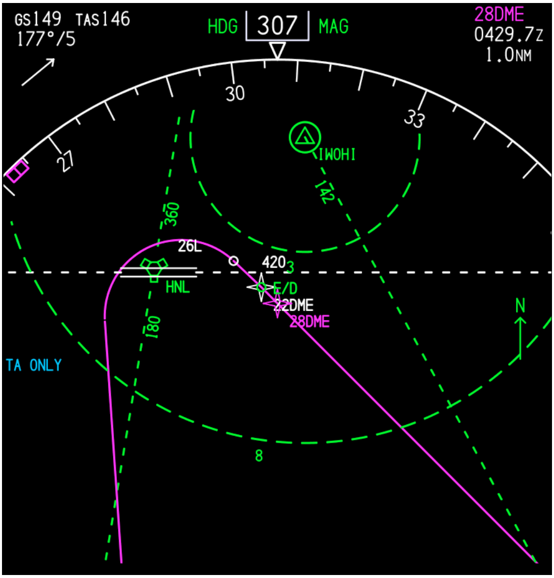


Time to go (TTG) to active waypoint replaces the ETA display when the onside NAV source selector is set to a CDU. TTG refers to minutes.

The **vertical path deviation indicator** appears when the FMC is in active descent mode, and when the glideslope is not captured. It indicates the deviation from the planned FMC descent profile. The outer edges of the scale equate to 400 ft.

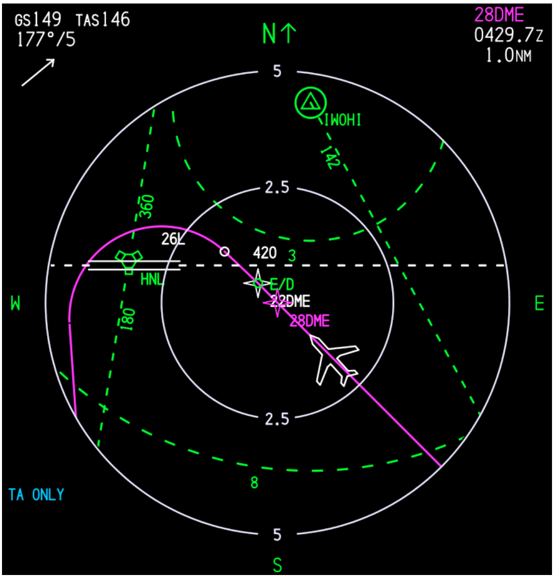


ND Plan Mode – VOR Radials – Fix Info:



A **CRT type plan mode**

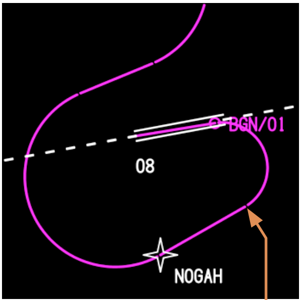
Dashed green symbols
The green symbology on this sample picture may also appear when in map mode, —on CRT and LCD types. The radial 180° from HNL is a VOR course entered on the FMC NAV RADIO page (course entries are only possible when the respective VOR is manually entered). The 142° bearing and the distance circles at 8 and 3 nm from IWOHI refer to entries on the FMC FIX INFO page.



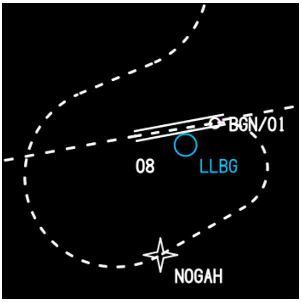
A **LCD type plan mode**
The nose of the moving aircraft symbol indicates the current aircraft position. Compared to the CRT plan, the LCD plan is slightly zoomed in.

On CRT and LCD types, the plan center always refers to **true north**, even if the heading reference is set to MAG. When PLN is first selected, the plan is centered on the active waypoint. The center can be set to other route waypoints by pushing the STEP key on the onside FMC LEGS page.

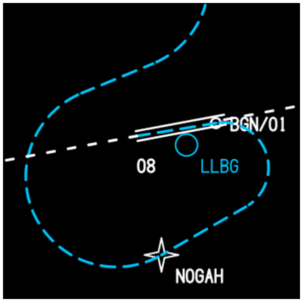
ND Route Depiction:



Active route
(magenta line)



Modified route
(white dashes)

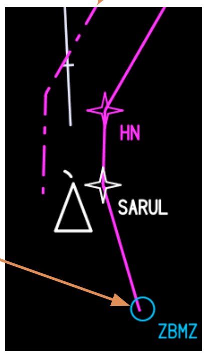


Inactive route
(cyan dashes)

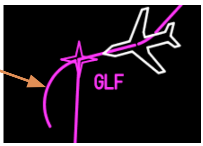
Segment separator
Black gaps indicate start and end of curves.

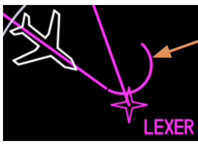
Offset route
(magenta dashes)

Origin/destination
Origin and destination airports of a route are displayed in cyan when no associated runway is entered. This feature is independent of the ARPT selection on the EFIS control.



Fly-*over* curve with **undefined** re-intercept course.



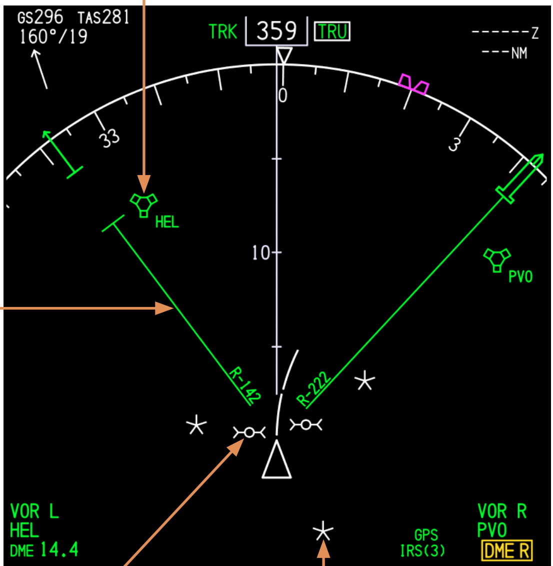


Fly-*by* curve with a course change greater than **135°**. In this case, the fly-by start is identical to that of a 90° change.

ND Position Check:

Tuned station
Tuned VORs and DMEs are displayed in green with reference to their database coordinates; they are always shown in MAP and PLN modes, regardless of the STA or POS selection on the EFIS control.

Raw data radial & distance
When POS is selected on the EFIS control, a green radial extends from the aircraft symbol to each tuned VOR. If the VOR is paired with a DME and DME data are received, a T-end is displayed at the respective distance, otherwise the radial extends to the compass rose edge. The green VOR symbols on the map refer to database coordinates. If there is no error, the database position agrees with the raw data indications on the map. Raw data always refers to magnetic north, while the compass rose may refer to magnetic or true north. On the picture to the right, the raw data radials disagree with the VOR database positions because the compass rose refers to true north.



GPS position
Two satellite symbols indicate the aircraft positions computed by GPS L and R.

IRU position
Three small white stars indicate the aircraft positions computed by IRU L, C, R.

GPS and IRU computed aircraft positions are displayed when POS is selected on the EFIS control. They are positioned relative to the FMC computed aircraft position which is indicated by the upper tip of the white triangle.

ND Energy Management Circles:

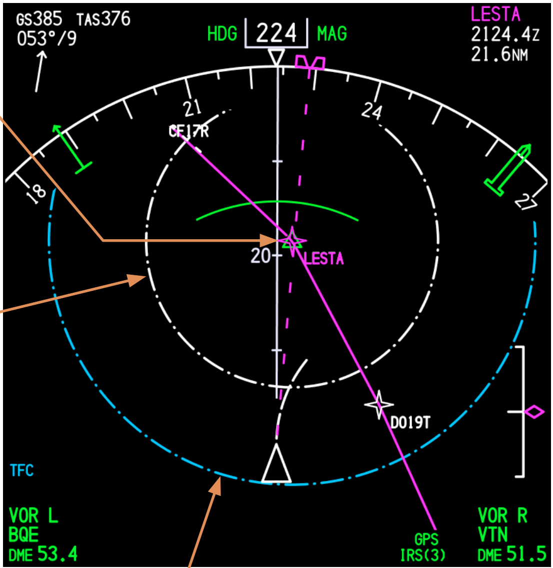
- Circles are based on VNAV predictions (more accurate than altitude range arc) to assist in idle descent planning when the aircraft is off the planned route (for example, due to ATC vectors).
- Descent profile is based on predicted winds, predicted temperatures, transition level, speed restrictions & transitions, anti-ice schedule, aircraft gross weight, and other performance data.
- Only applicable with flaps up, gear up, and throttles at idle.
- End of descent is the waypoint position and altitude entered on the FMC OFFPATH DES page.
- Circles are displayed when in MAP mode and when activated on the FMC OFFPATH DES page during arrival.

For more information refer to **OFFPATH DES Page** in chapter **FMS**.

Target waypoint
The green triangle indicates the center of the circles; that is, the end of descent.

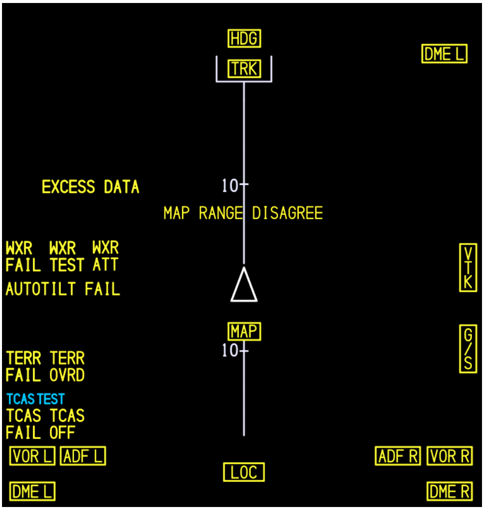
Speedbrake circle
The white dashed circle indicates the top of descent for idle descent with speedbrakes *fully extended* to the flight detent position. If the aircraft is inside the white circle, it will not reach the target altitude. If the aircraft is halfway between the white and cyan circle, the target will be reached with speedbrakes half extended.

A circle indicates the optimal top of descent *continuously*; for example, when the clean aircraft starts descending at the clean circle, the circle will shrink and—in the ideal case—follow the aircraft.



Clean circle
The cyan dashed circle indicates the top of descent for idle descent with speedbrakes *retracted*.

ND Test & Failure Flags:



HDG, TRK
Heading or track data are invalid; for example, because all three IRUs are not aligned while master FMC is operative, or because onside selected IRU is not aligned while master FMC is inoperative.

EXCESS DATA
STA, WPT, or ARPT selected on EFIS control, and not all symbols can be displayed within ND range. Only those nearest to the aircraft are displayed.

MAP RANGE DISAGREE
ND range disagrees with range reference of received data; for example, because the NAV source of the right ND is CDU C, and the left and right EFIS controls are set to different ND ranges (the CDU C map range is set by the left EFIS control only).

WXR RANGE DISAGREE
ND range disagrees with radar image reference *(WXR range disagreement is not modeled in the simulator).*

RSTR INOP
Raster display overheat *(the simulator models blackout and unstable displays, but not overheat).*

MAP
Invalid map data from master FMC.

WXR FAIL
Invalid data from selected weather radar system (WXR L or R).

WXR TEST
Weather radar system test is in progress.

WXR ATT
Due to system failure, weather radar antenna attitude no longer refers to horizon but to aircraft attitude.

AUTOTILT FAIL
Automatic weather radar antenna tilt control has failed.

TERR FAIL
EGPWS terrain function has failed.

TERR OVRD
TERR OVRD switch is pushed.

TCAS TEST
TEST switch on ATC panel is pushed and aircraft is on the ground.

TCAS FAIL
TCAS is inoperative.

TCAS OFF
TCAS is switched off on ATC panel.

VTK
No VNAV path data from master FMC.

VOR, ADF, DME, LOC, G/S
Invalid data from respective receiver.

Standby Magnetic Compass:

Magnetic heading indication
(For instrument lighting refer to chapter **Aircraft General**.)

Deviation correction card
Correction data are applicable when electrical power is connected to the aircraft.

(The simulator models all typical compass errors, which are: variation, deviation, magnetic dip, acceleration error, turning error, inertia effects, and attitude limits.)

Standby Attitude Indicator:

ILS not installed

ILS installed

MLS switch
Enables the standby ILS indication to operate in MLS mode. *(During the development of the simulator, there were, world-wide, no MLS approaches publicly available; hence, the MLS switch is currently not applicable.)*

Failure flags (orange)

GYRO Attitude indication is inoperative.

G/P ILS glideslope or MLS glidepath indication is inoperative.

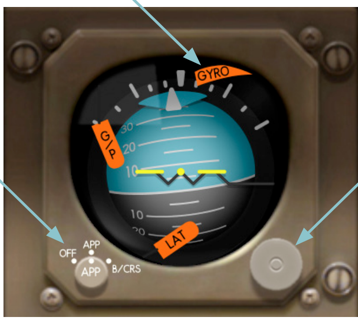
LAT ILS localizer or MLS azimuth indication is inoperative.

Approach selector

OFF Hides the needles.

APP Shows needles for ILS front course approach.

B/CRS Reverses the localizer needle orientation for back course approach.



Cage knob

Pull Levels the horizon with the yellow aircraft symbol. Knob must be pulled and held for some seconds on the ground after gyro power-up (powered by main battery bus).

For instrument lighting refer to chapter **Aircraft General**.

SYSTEM ANALYSIS

In the simulator, the gyro RPM of the standby attitude indicator is indicated on **Instructor > Analysis > Navigation**. 18000 RPM are required for normal operations.

Standby Airspeed Indicator:

Airspeed indicator
Indicates uncorrected airspeed. Uses lower left pitot (auxiliary 1), and alternate left and right static ports.

Airspeed bugs
Three white bugs can be positioned as required.

Standby Altimeter:

Altitude indicator
Indicates uncorrected altitude. Uses alternate left and right static ports. To provide smooth indicator motion, an internal vibrator operates continuously, powered by the main battery bus. Without vibration, when the aircraft starts leaving an altitude from level flight, the indicator will stick due to friction until the altitude difference is large enough to overcome the friction. *(In the simulator, when the vibrator fails, the stuck indicator can be released by clicking on the altimeter glass with the mouse.)*

Barometric setting control

Rotate Selects barometric setting displayed in hectopascals and inches of mercury.

For instrument lighting refer to chapter **Aircraft General**.

A Integrated Standby Flight Display (ISFD):

The ISFD is powered by its own battery which is charged by the main battery bus. The ISFD is deactivated if DC bus 3 is unpowered, and if the BATTERY switch and the STANDBY POWER selector on the overhead panel are set to OFF. The ISFD uses the lower left pitot and the alternate static ports. IRU L provides heading.

Approach selector

Push Cycles ILS indication status through APP (front course), BCRS (back course), and off.

Brightness switches

plus Push and hold to increase display brightness.

minus Push and hold to decrease display brightness.

Attitude reset switch

Push Hold the switch for 2 seconds to start 10 second attitude level alignment.

HP/IN selector

Push Alternately selects hectopascals or inches of mercury for barometric setting.

Brightness sensor

Senses the ambient light intensity, and accordingly modulates the display brightness.

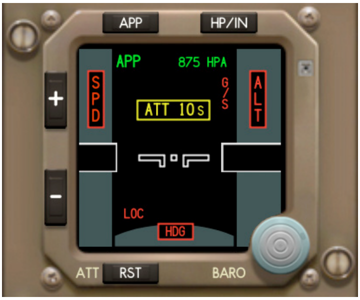
Barometric selector

Push Alternately activates standard or selected setting.

Rotate Selects barometric setting.

When ISFD is activated, self-test and internal laser gyro initialization starts:

Failure flags are displayed in red:



A Standby Radio Magnetic Indicator (RMI):

- RMI L is optionally installed on the captain's instrument panel, RMI R optionally on the first officer's.
- The heading sources are IRU R for RMI L, and IRU L for RMI R. For RMI power sources refer to chapter **Electrical**.
- When no VOR signal is received, the VOR pointer will park in 3 o'clock position.
- When no NDB signal is received, the ADF pointer will park in 9 o'clock position.

VOR L/ADF L selector

VOR Assigns the orange pointer to the left VOR.

ADF Assigns the orange pointer to the left ADF.

A A pink pointer may be installed instead of the orange one.

VOR R/ADF R selector

VOR Assigns the green pointer to the right VOR.

ADF Assigns the green pointer to the right ADF.

HDG flag

An orange HDG flag appears when the heading data from the respective IRU is invalid.

VOR/ADF flag

An orange flag appears when the data from the respective receiver is invalid.

For instrument lighting refer to chapter **Aircraft General**.

Clock:

Chronograph switch

Push Starts, stops, and resets the chronograph.

Two clocks are installed on the pilots' instrument panels. When GPS time is available, the FMS receives time and date from the GPS; else from the captain's clock if it is operative, else from the first officer's clock. ACARS uses the same priority logic to get time and date, unless ACARS uses its own clock system (requires ACARS DC power). The *displays* of the pilots' clocks are powered by the *APU* battery bus; if this fails, the clocks keep running and maintain their data. Only when the *main hot* battery bus is unpowered, the clock *electronics* are depowered; and when repowered, the times will restart at 00:00, 01/01/1995, requiring manual resetting. *(In the simulator, the clocks are automatically set to the current time when the time or season sliders are moved on **Instructor** > **Situation** > **Time**. However, as long as the sliders are not moved, each clock runs independently and can be set to a different time and date using the SET selector on the respective clock.)*

Chronograph second hand
Moves to 60 when reset.

Elapsed time/chronograph
Displays chronograph minutes when chronograph is not reset, else elapsed time in hours:minutes.

Date switch

Push Alternates between time and date modes.

Date & time display
In time mode: Displays time in hours:minutes:tenth of a minute.
In date mode: Flashes between a day & month display and a year display.

Elapsed time (ET) selector

RUN Runs the ET.

HLD Holds the ET.

RESET (spring loaded to HLD)
Resets the ET to zero.

Set selector

RUN Runs the time and the calendar.

HLDY In time mode: Holds the time and resets the seconds to zero.
In date mode: Advances the years.

MSM In time mode: Advances the minutes.
In date mode: Advances the months.

HSD In time mode: Advances the hours.
In date mode: Advances the days.

Advance process starts 2 seconds after selector movement, then advances the selected parameter every 1 second.

EICAS Messages:

CAUTION MESSAGES (accompanied by caution light and beeper sound)		
A >AIRSPEED LOW		airspeed is below minimum maneuvering speed
>ATTITUDE		captain's and first officer's bank or pitch indications disagree by 3° or more
>SNGL SOURCE ILS		both pilots use the same G/S source or LOC source

ADVISORY MESSAGES		
>ADC ()		ADC (LEFT, CENTER, or RIGHT) has failed
A >AIRSPEED LOW		airspeed is below minimum maneuvering speed
>BARO DISAGREE		barometric settings of left and right EFIS controls disagree by at least 0.04 inches of mercury for more than 1 minute
>EFIS CONTROL ()		one EFIS control panel (L or R) has failed
>EFIS/EICAS C/P		both EFIS control panels have failed
>EIU ()		EIU (LEFT, CENTER, or RIGHT) has failed
>HEADING		captain's and first officer's heading indications disagree by 4° or more
>IAS DISAGREE		captain's and first officer's airspeed indications disagree by 5 kt or more
>SNGL SOURCE RA		both pilots use the same radio altimeter
>SOURCE SEL ADC		both pilots have selected the same ADC source
>SOURCE SEL EIU		both pilots have selected the same EIU source
>SOURCE SEL F/D		both pilots have selected the same F/D source
>SOURCE SEL IRS		both pilots have selected the same IRS source
>SOURCE SEL NAV		both pilots have selected the same NAV source

MEMO MESSAGES		
A VMO SPARE ENGINE		5th engine carriage mode is active which reduces maximum operating speed (VMO) tape on PFDs to 330 kt/M.85 and adjusts FMC command speeds and drag data accordingly *[GE engines cannot be carried]*

EICAS Messages:

STATUS MESSAGES		
ADC ()		ADC (LEFT, CENTER, or RIGHT) has failed
EFIS CONTROL ()		EFIS control panel (L or R) has failed
EIU ()		EIU (LEFT, CENTER, or RIGHT) has failed
GND TEST ENABLE		ground tests are enabled
IDS DU		at least one IDU has failed

Limitations in the Simulator:

The caution message >ALT DISAGREE can not occur because static port failures or excessive ADC altitude miscalculations are not modeled (altitude disagreements due to *barometric missettings* are covered by the message >BARO DISAGREE). The following status messages are not included as the respective faults are not modeled:
EIU DISAGREE, FLIGHT RCDR SYS, IDS ENG DATA MON, IDS SOFTWARE.

FMS

System Overview:

FMS stands for **flight management system**, in maintenance terms sometimes specified as flight management computer system (FMCS). The system comprises two **flight management computers (FMCs)** labeled as FMC L and R; they are connected with each other and share the same data. The FMCs are installed outside the flight deck in the main equipment center.

On the flight deck, the crew controls and monitors the FMCs through two **multipurpose control display units** (MCDUs), or **CDUs** for short; they are labeled as CDU L and R. Each of the two CDUs can be linked with either FMC L or R.

A third CDU, labeled as CDU C, cannot control the FMCs, but every CDU—L, R, and C—stores a simplified copy of the current FMC route waypoints in volatile CDU memory; these waypoints can be displayed on the NDs for standby navigation in case of dual FMC failure. Also, when both FMCs fail, all three CDUs provide manual backup tuning controls for the navigation radios.

In summary, the FMS provides:

- Automatic and manual tuning control of VOR, DME, and ILS/MLS receivers; and manual tuning control of ADFs.
- Aircraft position calculation by evaluating and combining the data from VORs, DMEs, localizers, IRUs, and GPS units.
- Lateral and vertical guidance to the autopilot & flight director system (refer to **LNAV** & **VNAV** in chapter **Automatic Flight**).
- Autothrottle servo control (refer to chapter **Automatic Flight**), engine trim equalization commands (refer to chapter **Power Plant**), and thrust limit management.
- Touchdown zone and V speed markers on PFDs, navigational displays on ND maps and plans (refer to chapter **Flight Instruments**), and thrust management data on the EICAS (refer to chapter **Power Plant**).
- Information in textual form on CDUs regarding aircraft performance and navigation, along with the possibility to modify the data by crew inputs.
- FANS-1 implementation for CPDLC (textual ATC communication).

Inputs and Outputs:

The FMS **receives** data from the following components:
- ACARS/VHF module
- ADCs & ADC source selectors
- Air/ground system
- Autothrottle servo tachometer, and A/T disconnect switches
- CDUs
- Clocks
- CMC *(in the simulator not available)*
- COM (VHF & HF radio activity status)
- Data loader
- EFIS control
- EIU (fuel flow, N1, N2, and other engine data)
- Flight control computers
- FMC master relays & master switch
- Fuel quantity indicating system (FQIS)
- GPS positions and times
- Heading reference switch
- Navigation radios (raw data from VOR, DME, and ILS)
- IRUs
- MCP
- Navigation source selectors
- Offside FMC (synchronization data)
- Printer (device status)
- A Weight & balance computers

The FMS **sends** data to the following components:
- ACARS MUs
- ACMS *(in the simulator not available)*
- Autothrottle servo
- Cabin pressurization control system
- CDUs
- Data loader
- EECs
- EIUs
- Flight control computers
- Ground proximity warning system
- Navigation radios (settings for ADF, VOR, DME, and ILS/MLS)
- IDUs
- IRUs
- MAWEA
- Offside FMC (synchronization data)
- Printer

Memory Systems and Databases:

Nonvolatile FMC memory

Each FMC incorporates a nonvolatile, magnetic-bubble memory system that will not lose stored data when power is removed. It stores:

- Two navigation databases *(in the simulator, one database simulates two)*
- An aerodynamics & engine database (performance database)
- Three routes (route 1 & 2, and a buffer for route modifications)

The FMC only erases the routes when the crew swaps the active with the inactive navigation database (refer to **IDENT Page** in this chapter).

Volatile FMC memory

Each FMC also stores pilot entered initialization and reference data such as gross weight, cost index, takeoff settings and other variables; these will be lost when the respective FMC is unpowered for more than circa 30 seconds. When an FMC is repowered while the other FMC is operating and containing data, that other FMC will resend the data to the repowered FMC.

Volatile CDU memory

Each CDU stores route waypoints defined by fixed latitudes and longitudes for standby navigation. The CDU memory is erased when the respective CDU is unpowered for more than circa 30 seconds. When a CDU is repowered while the associated FMC is operative, that FMC will resend all non-conditional waypoints of the active route to this CDU's memory. Otherwise, under standby conditions, waypoints need to be entered into the CDU manually. The three CDUs do not share their data with each other.

A Weights are indicated either by kg x 1000, or lb x 1000, as per FMC software option configuration.

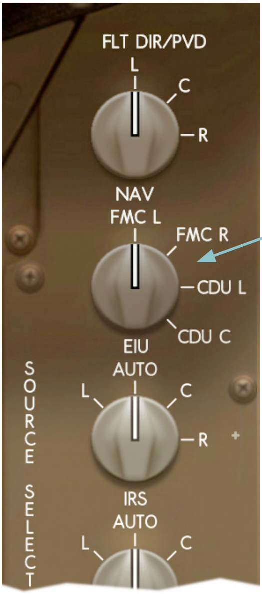
Flight Completion:

Flight completion is the event when all engines are shut down while the aircraft is parked on the ground. This event signals the FMCs to erase the initialization and reference data, and the active route (not the inactive route); it also commands all CDUs to clear their route memory.

FMC Master Selection:

FMC master switch
The selected FMC operates as the master FMC. Each of the two FMCs operates independently, but the master FMC is used as a reference for data synchronization with the other FMC. The master FMC also sends data to other systems. In case of a single FMC failure, the FMS remains serviceable as long as the remaining operative FMC is the master; in such a case the crew checks that the master switch is set to the operative FMC. (When the master switch is moved, the autothrottle disengages; it then must be re-engaged manually.)

Navigation Source Selection:



Captain's navigation source selector
The selected *CDU*—L or C—provides standby navigation data to the captain's ND. The selected *FMC* provides data to the captain's PFD and ND, and is linked with the screen and keys of CDU L.

F/O's navigation source selector
The selected *CDU*—R or C—provides standby navigation data to the F/O's ND. The selected *FMC* provides data to the F/O's PFD and ND, and is linked with the screen and keys of CDU R.

CDU Screen Conventions:

Page title
Flight plan related page titles may be preceded by MOD or ACT, indicating that the information on the entire page is either modified or actively in use. Modified data become active when the EXEC key is pushed, or are canceled when the respective page's <ERASE prompt is selected. If multiple related pages exist, the page title is followed by a page number, a slash, and the total amount of pages, for example, 1/3; such pages may be accessed through the PREV PAGE and NEXT PAGE keys.

Boxes
Indicate that information must be entered by the crew to enable essential FMC features.

Dashes
Indicate that information may be entered by the crew for optional features.

Line title
Describes in small font the type of data shown below that line title.

Entry in small font
Indicates that the data is provided by the computer and may be manually overwritten by data from the scratchpad; or, in a simpler way, if a > caret is shown, may be *verified* by selecting that caret while the scratchpad is blank.

Entry in large font
Indicates that the information is entered or verified by the crew.

Scratchpad
Information in scratchpad is an FMC generated message if the MSG light is on, otherwise it is manually entered or it is data downselected from a line.

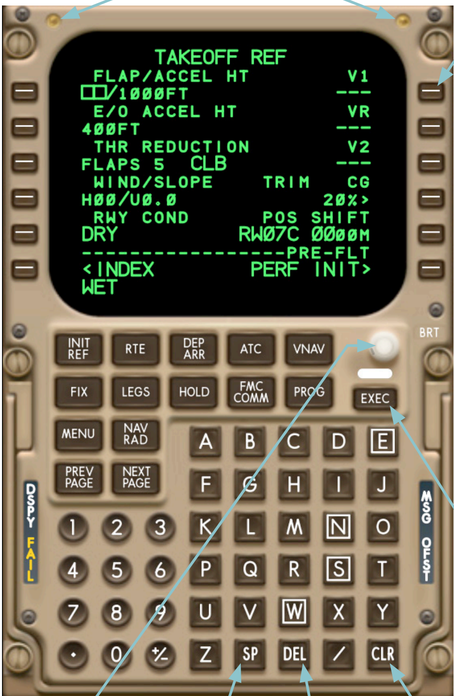
CDU Controls:

Brightness sensors
Sense the ambient light intensity, and accordingly modulate the screen brightness.

All CDU keys are momentary action switches.

Line select key
(LSK 1L to 6L; LSK 1R to 6R)

- Transfers the data from the scratchpad up to the selected line if the FMC allows entries into that line. If entries are generally not allowed, there will be no effect; if entries are allowed but the entered format is invalid, the message INVALID ENTRY will appear.
- Transfers the data shown in the selected line down to the scratchpad if the scratchpad is blank and if the FMC allows downselection from that line.
- Deletes or resets the data shown in the selected line if the DELETE message is activated by the DEL key and if deletion is allowed. Some lines will activate the message INVALID DELETE when deletion is not allowed.
- Opens another page or activates a function when the line contains a > caret pointing at the LSK.



EXEC key
Executes modified or armed inactive data, and extinguishes the white light above the switch.

BRT selector
Rotate to set the screen brightness.

SP key
Writes a space character.

DEL key
Activates the DELETE message if the scratchpad is blank.

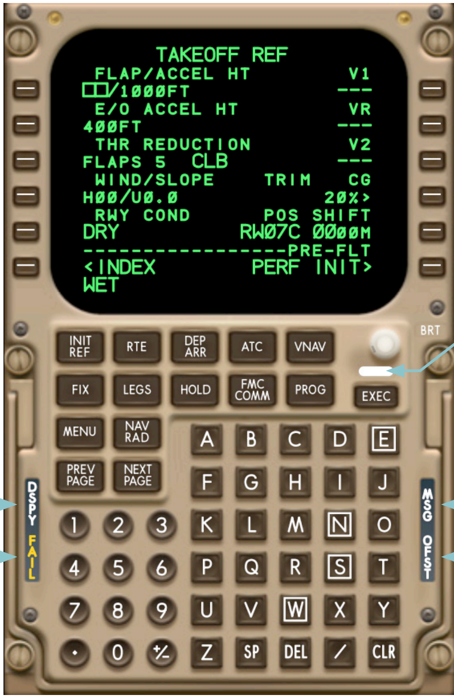
CLR key
Clears the message displayed in the scratchpad if the MSG light is on, otherwise clears the last character or, when held for 1 second, clears all characters at once.

CDU Lights:

(There is an old and a new version of the CDU front plate; the simulator models the new version only.)

DSPY light
Indicates that the displayed page refers to a route leg that is not the active leg, or to a performance mode not related to the current mode.

FAIL light
Indicates that the FMC associated with this CDU has failed.



EXEC light
Indicates that the displayed page contains modified data or an inactive route armed for activation, and that the EXEC key is enabled to activate the data.

MSG light
Indicates that the scratchpad contains a message.

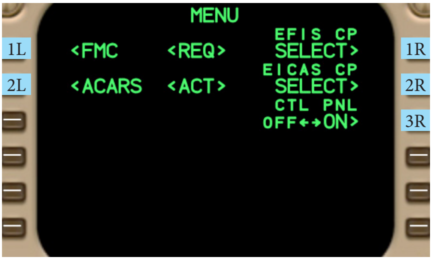
OFST light
Indicates that LNAV is guiding along an offset route.

CDU Keyboard Handling in the Simulator:

The CDU keys can be actuated by the mouse or by the PC keyboard. To connect the PC keyboard with CDU L, push and release the left SHIFT key; for CDU R, push and release the right SHIFT key; for CDU C, hold any SHIFT key and CTRL key simultaneously, then release the SHIFT and then the CTRL key. To disconnect a CDU, push and release any SHIFT key.—The keyboard connection can be indicated by a cyan flag in the upper left corner of the simulator frame.

The numerical pad on the right-hand side of the PC keyboard actuates the numerical CDU keys. The PC keys 1 to 6 on the keyboard's upper row actuate LSKs 1L to 6L; and the PC keys F1 to F6 actuate LSKs 1R to 6R. For more information refer to chapter **Simulator Handling**.

MENU Page:



Access: MENU key

General: Shows all available subsystems that can be linked with this CDU. <ACT> indicates which subsystem is currently linked. One CDU can handle one subsystem at a time. <REQ> indicates that the respective subsystem has generated a message requiring crew attention.

1L **<FMC**

Enables this CDU to control and monitor that FMC which is selected by the onside pilot's NAV source selector. Opens the IDENT page if FMC initialization data have been reset, otherwise opens the last page used. On CDU C, or when the associated onside FMC is inoperative, the <FMC key is blank.

2L **<ACARS**

Selection enables this CDU to control and monitor certain ACARS functions. Selection opens the ACARS INDEX page. Selection is inhibited when ACARS has already been selected on another CDU. For operational details refer to **ACARS – Index Page** in chapter **Communications**.

1R **EFIS CP SELECT>**

Opens the EFIS CONTROL page. Key is blank on CDU C, or when 3R is selected OFF. For EFIS control functions refer to **Alternate EFIS Control** in chapter **Flight Instruments**.

2R **EICAS CP SELECT>**

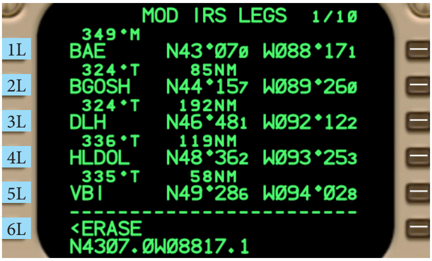
Opens the EICAS CONTROL page. Key is blank on CDU C, or when 3R is selected OFF. For EICAS control functions refer to **Alternate EICAS Control** in chapter **Warning Systems**.

3R **CTL PNL OFF-ON>**

Enables or disables the keys at 1R and 2R. Key is blank on CDU C. When selected ON, the onside EFIS control panel is deactivated.

(In the simulator standard package, the subsystems available are FMC L, FMC R, standby navigation systems in the three CDUs, ACARS, EFIS control L, EFIS control R, and EICAS control. Non-standard third-party subsystems may be added through the simulator's main network.)

IRS LEGS Page:



1L 2L 3L 4L 5L Leg information
Indicates the respective leg course with reference to magnetic (M) or true (T) north. The heading reference switch status is only applied to the first leg; the other legs always refer to true north. Also indicates the leg distance, waypoint name, and the waypoint coordinates. Waypoint names containing up to five letters refer to waypoints carried over from the FMCs. Downselecting such a waypoint will display the name in the scratchpad. Downselecting a pilot entered waypoint will display the coordinates in the scratchpad.

Valid entries
Any waypoint name that is already in the route (copied from FMCs before FMCs failed), or coordinates. For example:
For N27° 59.7' E086° 55.8'
enter N2759.7E08655.8
For N27° 00.0' E086° 00.0'
enter N27E086

6L <ERASE
Displayed when the route is modified. Pushing the key cancels the modification and extinguishes the EXEC light.

Access: LEGS key

General: Accessible on CDU L or R when respective onside FMC fails; on CDU C when both FMCs fail. During normal FMC operation, each CDU stores the waypoint names and coordinates of the active FMC route for backup purposes. Whenever the active FMC route changes, the FMCs update the backup copies in the CDUs. Conditional waypoints are not copied; they are replaced by route discontinuities.

When the associated FMC fails, the CDU has control over its stored route waypoints. Each CDU receives aircraft position data from a different IRU. As IRU positions drift individually, each CDU will sequence the active waypoint at slightly different times and locations. Also, in case of FMC failures, when a route modification is to be entered, the crew needs to enter this on every CDU as there is no data transfer between CDUs. Modifications become active by pressing the EXEC key on each CDU, or are canceled by selecting the <ERASE prompt on each CDU.

Navigation using the CDU software, without FMCs, is referred to as *standby navigation*. Under this condition, LNAV and VNAV are not available: the CDU route must be followed on the ND using HDG SEL and other AFDS modes.

To view the CDU routes on the NDs, each pilot sets the onside NAV source selector to the respective CDU.

In *standby navigation*, groundspeed based fly-by curve radiuses are only computed for the first two legs.

IRS PROGRESS Page:

Access: PROG key

General: Accessible on CDU L or R when respective onside FMC fails. Accessible on CDU C when both FMCs fail. Each CDU receives inertial reference data from a different IRU, and each CDU route can be modified individually; hence, the values displayed may vary from CDU to CDU.

1L LAST

Indicates the last sequenced route waypoint and the aircraft altitude at that waypoint.

2L TO

Indicates the active waypoint, the distance to go (DTG) along the route to that waypoint, and accordingly the time to go (TTG) in *hours:minutes* format.

3L NEXT

Indicates the next waypoint after the active one, the distance to go (DTG) along the route to that waypoint, and accordingly the time to go (TTG) in *hours:minutes* format.

4L DEST

Indicates the destination airport (copied from the FMCs before the FMCs failed), the distance to go (DTG) along the route to that destination, and accordingly the time to go (TTG) in *hours:minutes* format.

Line title DEST is replaced by line title ENROUTE WPT when a route waypoint is entered, in which case the data in the line will refer to the along-route distance and time to that entered waypoint.

Line title reads DIR TO ALTERNATE when off-route coordinates are entered, in which case the data in the line will refer to the great circle distance and TTG direct to these coordinates.

Valid entries

Any waypoint name contained in the route (copied from FMCs before FMCs failed), or coordinates. For example:

For N27° 59.7’ E086° 55.8’
enter N2759.7E08655.8

For N27° 00.0’ E086° 00.0’
enter N27E086

5L IRS (L, C, or R)

Indicates aircraft position and groundspeed computed by the IRU linked with this CDU.

6L XTK ERROR

Indicates current crosstrack error, followed by the desired track (DTK) and the current track (TK). Track angles are based on the selected heading reference, which refers either to magnetic (M) or true (T) north.

ALTN NAV RADIO Page:

Access: NAV RAD key

General: The page is available when both FMCs fail, and is then accessible on all three CDUs. As each CDU controls a different ILS-MLS receiver, data may vary from CDU to CDU. Also: CDU L refers to the left VOR/ADF; CDU R to the right VOR/ADF; CDU C has no VOR/ADF.

1L VOR

Indicates the frequency of the tuned VOR or DME, followed by the A or M tuning status (automatic or manual) that was present when the FMCs failed (autotuning is not continued when the FMCs are inoperative).

Valid entries
VOR or DME frequency:
XXX.X
XXX.XX
Frequency/course (000-360):
XXX.X/XXX
XXX.XX/XXX

2L CRS

Indicates the entered course for the tuned VOR, or dashes when the course is deleted. Indication is blank when the VOR has been tuned automatically.

Valid entries
Course (0-360):
X
XX
XXX
Frequency/course (000-360):
XXX.X/XXX
XXX.XX/XXX

3L ADF

Indicates the frequency of the tuned ADF, followed by ANT when in antenna mode, or BFO when in BFO mode. ANT and BFO modes can be removed by line deletion.

Valid entries
NDB frequency:
XXX
XXXX
XXX.X
XXXX.X
Tuning mode:
A
B
Frequency and tuning mode:
XXXA
XXXX.XB

(continued next page)

ALTN NAV RADIO Page: *(continued)*

4L **ILS-MLS**
Indicates ILS frequency/course or MLS channel/azimuth, and A or M tuning status (automatic or manual) that was present when the FMCs failed (autotuning is not continued when the FMCs are inoperative).

Valid entries

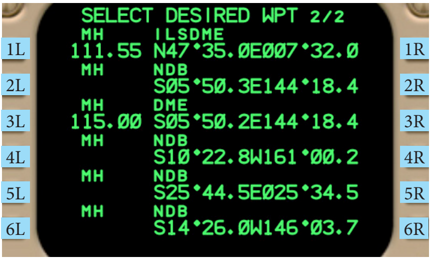
ILS frequency/course:
 XXX.X/ XXX
 XXX.XX / XXX
ILS course after slash:
 / XXX

MLS channel/azimuth:
 XXX / XXX
MLS azimuth after slash:
 / XXX

6L 6R **PRESELECT**
Data may be preselected for later transfer.

Valid entries
All formats valid on this CDU page.

SELECT DESIRED WPT Page:



Access: Automatically displayed when an identifier of a database fix is entered on an FMC page that allows fix entries, and multiple fixes of the same identifier exist.

General: Provides details and keys to select the desired fix to be entered on the previously displayed FMC page. Selection is canceled when another page is opened.

Any key left or right
Selects the fix displayed in the same line. Each line shows the identifier, the type of fix, the coordinates and, if applicable, the frequency (the FMC database does not contain NDB frequencies.). When a fix entry was attempted on a RTE or LEGS page, the listed fixes are sorted by their distances from the adjacent, previous leg waypoint. Otherwise, the listed fixes are sorted by their distances from the aircraft. The nearest fix is displayed first. Up to 12 fixes may be displayed on two pages.

(In the simulator, when a situation is saved while the SELECT DESIRED WPT page is displayed on a CDU, reloading this situation will start with the MENU page displayed on that CDU. This is a protection feature as the user cannot know what previous FMC page the selection referred to.)

PROGRESS 1/3 Page:

Access: PROG key

General: Shows progress data regarding the active or modified route. The page title is preceded by the flight number entered on the RTE page.

1L LAST
Indicates the last sequenced route waypoint; and the aircraft altitude, actual time of arrival (ATA), and actual fuel remaining at that waypoint.

2L TO 3L NEXT
Indicates the distance to go (DTG) along the route, and the estimated time of arrival (ETA) and fuel remaining, with reference to the active (TO) and the next waypoint.

5L Speed indication
Indicates the same speed information as shown on the VNAV pages. For details, refer to **VNAV page** in this chapter.

6L <POS REPORT
Opens the POS REPORT page.

5R TO (T/C, S/C, T/D, E/D, LEVEL AT)
Shows the same data as on the VNAV pages. Refer to **VNAV page** in this chapter.

6R POS REF>
Opens the POS REF page.

4L DEST
Indicates the destination airport, the distance to go (DTG) along the route to that airport, and the estimated time of arrival (ETA) and fuel remaining at that airport.

Line title reads ENROUTE WPT when a route waypoint is entered, in which case the data in the line will refer to the along-route distance to, and ETA at, that waypoint.

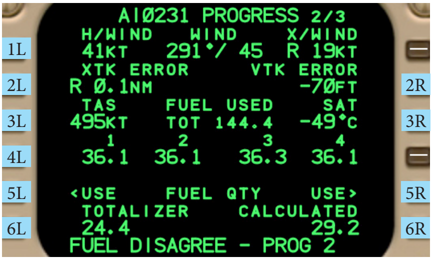
Line title reads DIR TO ALTERNATE when an off-route waypoint is entered, in which case the data in the line will refer to the great circle distance direct to that waypoint.

Line title resets to DEST when both CDUs are not on this page, or when line is deleted.

MOD DEST is indicated when the route is modified and data refer to the modification.

Valid entries
Any waypoint, station, or airport identifier in the database or route; or coordinates, for example:
For N27° 59.7’ E086° 55.8’
enter N2759.7E08655.8
For N27° 00.0’ E086° 00.0’
enter N27E086
Destination runway, for example:
For runway 07 enter RW07 or 07.
Place-bearing/distance, for example:
For 5 nm from JFK on 090° bearing
enter JFK090 / 5
Place-bearing/place-bearing, for example:
For the intersection of JFK bearing 270° with LGA bearing 180°
enter JFK270 / LGA180

PROGRESS 2/3 Page:



Access:
PROG key, then NEXT PAGE key.

General:
Shows path error related data and fuel progress details. The page title is preceded by the flight number entered on the RTE page.

1L Wind data
Indicates headwind (H) or tailwind (T), wind direction and speed, and crosswind (X). Reference is true north. Line is blank when TAS is below 100 kt.

2L XTK ERROR
Indicates current left or right aircraft crosstrack deviation from active route.

3L TAS TOT FUEL USED
Displays current ADC computed TAS when above 100 kt, otherwise the display is fixed at 100.—Indicates in the middle of the line the total fuel used since engine start.

4L Fuel used per engine
Indicates the fuel used by each engine based on EIU fuel flow data.

5L <USE TOTALIZER
Displayed when the totalizer quantity differs from the calculated by more than 4080 kg (9000 lb). When selected, CALCULATED data blanks and FMC will use FQIS totalizer data for fuel quantity references.

6L TOTALIZER
Displays totalizer data from FQIS (fuel levels sensed in tanks). Blank if fuel on PERF INIT page is entered manually.

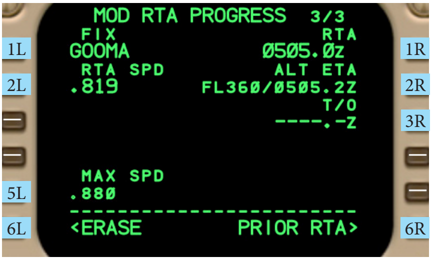
2R VTK ERROR
Indicates the aircraft's current vertical deviation from the planned VNAV descent path. Blank when VNAV is not in the descent phase.

3R SAT
Displays current ADC computed static air temperature.

5R USE> CALCULATED
Displayed when the totalizer quantity differs from the calculated by more than 4080 kg (9000 lb). When selected, TOTALIZER data blanks and FMC will use calculated, fuel flow based data for fuel quantity references.

6R CALCULATED
Displays calculated total fuel quantity remaining based on recorded fuel flow since engine start. Blank when all EIUs fail.

RTA PROGRESS 3/3 Page:



Access: PROG key, then PREV PAGE key; or 6L on VNAV CRZ page.

General: Provides controls for the required time of arrival (RTA) function. Page title is preceded by ACT or MOD when the displayed data are active or modified. The RTA function is available in the VNAV cruise phase only.

1L FIX

Displays the enroute fix the RTA refers to. Deletion and execution returns RTA speed mode to ECON speed mode.

Valid entries
Any waypoint in the cruise section of the route.

2L RTA SPD

Displays the computed speed necessary to reach the fix at the entered RTA. Speed is based on wind and performance predictions along the route. Blank when not in VNAV cruise phase, or when no fix is entered.

5L MAX SPD

Displays the maximum allowable RTA speed. If it is lower than the hold speed, the hold speed is the maximum. Deletion resets the maximum to the default value .880.

Valid entries
Mach number (.100 to .990):
.X
.XX
.XXX

6L <ERASE

Displayed when data is modified. Selection cancels the modification.

1R RTA

Displays the RTA. Deletion and execution returns RTA speed mode to ECON speed mode. Blank when no fix is entered.

Valid entries
Time (0000.0 to 2359.9):
XXXX
XXXX.X
Then *at-or-after* (A), or *at-or-before* (B):
A
B
Time with trailing A or B:
XXXXA
XXXX.XB

2R ALT ETA

Predicted altitude and ETA at entered fix.

3R T/O

Planned takeoff time. Blank in flight. Adjusts the ETAs of all route waypoints.

Valid entries
Time (0000.0 to 2359.9):
XXXX
XXXX.
XXXX.X

6R PRIOR RTA>

Selection re-enters previous RTA settings.

NAV RADIO Page:

Access: NAV RAD key

General: Provides tuning and monitoring functions for all navigation radios installed on the aircraft.

1L VOR L 1R VOR R

When a frequency is entered, the FMC adds the next suitable database identifier; when an identifier is entered, the FMC adds the next suitable database frequency. Also shows the tuning status:

M Manual tuning — The crew has selected this station. Deletion cancels this mode.

A Autotuning — The FMC has selected this station because its location relative to the aircraft is ideal for the FMC's aircraft position calculation.

R Route tuning — The FMC has selected this station because it is a required enroute station on the active route.

P Procedure tuning — The FMC has selected this station because it is a required station in the current SID, STAR, or approach.

Valid entries
VOR or DME identifier (1 to 3 letters):
XXX
VOR or DME frequency:
XXX.X
XXX.XX
Frequency/course (000-360):
XXX.X/XXX
XXX.XX/XXX
Identifier (1 to 3 letters)/course (000-360):
XXX/XXX

2L CRS (L) 2R CRS (R)

Indicates the entered course for the tuned VOR, or dashes when the course is deleted. Indication is blank when the VOR is not manually tuned. Indicates in the middle of the page the received raw data radials of the left and right VORs.

Valid entries
Course (0-360):
X
XX
XXX
Frequency/course (000-360):
XXX.X/XXX
XXX.XX/XXX

3L ADF L 3R ADF R

Indicates the frequency of the tuned ADF, followed by ANT when in antenna mode, or BFO when in BFO mode. ANT and BFO modes can be removed by line deletion.

Valid entries
NDB frequency:
XXX
XXXX
XXX.X
XXXX.X
Tuning mode:
A
B
Frequency and tuning mode:
XXXA
XXXX.XB

(continued next page)

NAV RADIO Page: *(continued)*

4L **ILS-MLS**

Indicates ILS frequency/course or MLS channel/azimuth, and tuning status:

M Manual tuning — The crew has selected this station. Inhibits autotuning. Line deletion activates autotuning mode.

A Autotuning — The FMC has selected this station because the crew has selected an approach to a runway equipped with ILS or MLS. Manual entry activates manual tuning mode.

Data is replaced by the word PARK when in autotuning mode and when either of the following two conditions is true:

- Aircraft is not within 200 nm of T/D.
- Aircraft is closer to the origin airport than to the destination airport.

Otherwise, autotuned data is shown in small font with a caret, for example:

<109.50/090°PARK

It will return to big font and the caret and PARK word will disappear in any of the following cases:

- Aircraft is within 150 nm of destination.
- Aircraft is within 50 nm of T/D.
- Aircraft is in VNAV descent phase.
- Crew selects this caret.

When the crew selects this caret, the FMC returns to manual tuning mode.

Valid entries

ILS frequency/course:
XXX.X/XXX
XXX.XX/XXX
Course if frequency is manually entered:
/XXX

MLS channel/azimuth:
XXX/XXX
Azimuth if channel is manually entered:
/XXX

ILS tuning is inhibited in any of the following cases:

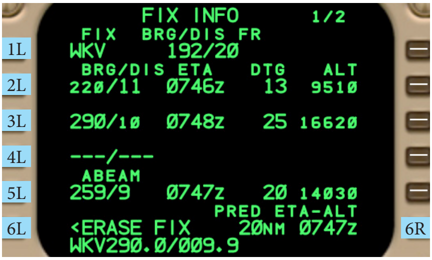
- Any autopilot is engaged, and LOC or G/S mode is engaged.
- Any flight director is engaged, and LOC or G/S mode is engaged, and radio altitude is below 500 ft.
- Aircraft is on the ground, and heading is within 45° of localizer front course, and groundspeed is greater than 40 kt.

6L 6R **PRESELECT**

Data may be preselected for later transfer.

Valid entries
All formats valid on this CDU page.

FIX INFO Page:



Access: FIX key

General: The crew can enter a database fix with bearings and distance circles for display on the NDs. Bearings refer to magnetic or true north as per the current FMC heading reference. The data is blank when the distance is greater than 511 nm. Two pages are available.

1L FIX

When a fix is entered, bearing and distance from the fix are shown in the middle of the line, and all left LSKs are operative.

Valid entries
Any waypoint, airport, or navigation radio identifier in the database.

2L 3L 4L BRG/DIS

Values in small font are computed data, values in large font are manual entries.
If a bearing or circle intersects a straight segment of the active route, the estimated time of arrival (ETA), distance to go (DTG), and altitude at that intersection are indicated. Downselecting a small-font entry will show that intersection in the scratchpad in place-bearing/distance format.

Valid entries
Bearing (000-360):
XXX
Distance (1-511) after slash:
/XXX
/XX
/XXX
Bearing/distance:
XXX/X
XXX/XX
XXX/XXX

5L ABEAM

Initially displays the <ABEAM prompt. When selected, the FMC computes the next possible route intersection that is abeam the entered fix and located on a straight leg segment. The NDs will show a line from that intersection to the fix.
If no such abeam intersection is found, INVALID ENTRY appears. The other functions in 5L are the same as those in 2L, 3L, 4L.

6L <ERASE FIX

Erases the entries in 1L to 5L and removes the respective data from the NDs.

6R PRED ETA-ALT

Predicts the distance to go along the active route to the entered time or altitude. The NDs show the predicted point as a small green circle.

Valid entries
Time with a trailing Z (0000Z-2359Z):
XXXXZ
Altitude (crossing a climb or descent leg):
XXX
XXXX
XXXXX
FLXXX

Access to Initialization and Reference Pages:

When the INIT REF key is pushed, the FMC automatically opens an initialization or reference page relevant to the current system status.

On ground
and IRS not aligned
and IRS position not set.

On ground, and gross weight, fuel reserves, cost index, cruise altitude not set.

On ground and all set.

In VNAV CLB.

In VNAV CRZ or DES.

INIT/REF INDEX Page:

Access:
6L on any indexed page

General:
Displays an index of all pages related to the initialization, reference, and maintenance of the FMC and IRS. All indexed pages provide an <INDEX key at 6L that opens this index.

1L **<IDENT**
Opens the IDENT page.

2L **<POS**
Opens the POS INIT 1/3 page if the aircraft is on the ground or any IRU is in ATT mode, otherwise opens POS REF 2/3 page.

3L **<PERF**
Opens the PERF INIT page.

4L **<THRUST LIM**
Opens the THRUST LIM page.

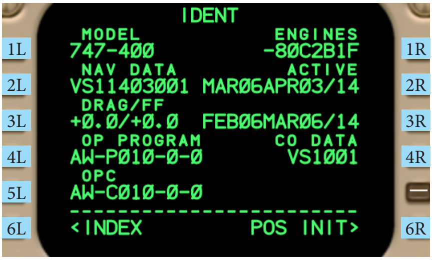
5L **<TAKEOFF**
Opens the TAKEOFF REF page.

6L **<APPROACH**
Opens the APPROACH REF page.

1R **NAV DATA>**
Opens the REF NAV DATA page.

6R **MAINT>**
Opens the MAINTENANCE INDEX page. Key is blank and access is inhibited when the aircraft is in flight.

IDENT Page:



Access:
- 1L on INIT/REF INDEX
- 1L on MENU after FMC power-up

General: Displays information regarding the navigation and performance databases.

(The simulator incorporates just one physical navigation database; the date display on the IDENT page is a simulation.)

1L MODEL
Indicates the aircraft model the installed performance database refers to. The possible model codes are: -400M (combi), -400F (freighter), -400 (passenger), -400F.1 (ER freighter), and -400.1 (ER passenger).

2L NAV DATA
Shows the navigation database identifier. The order of the characters: 1 & 2 identify the airline, 3 the database number, 4 & 5 the production year, 6 & 7 the cycle number, and 8 to 10 the sequence number.

3L DRAG/FF
Indicates the aircraft drag and fuel flow correction factors that are entered on the PERF FACTORS page.

4L OP PROGRAM
Shows the identifier of the installed FMC software. If there is an identifier disagreement between FMC L and R, the FMCs are locked up on the IDENT page.

5L OPC
Shows the identifier of the installed FMC software configuration options.

6L <INDEX
Opens the INIT/REF INDEX page.

1R ENGINES
Shows the engine identifier the installed performance database refers to. The possible identifiers are: On non-ER aircraft -80C2B1F (GE), PW4056 (PW), RB211-524G (RR); on ER aircraft -80C2B5F (GE), PW4062 (PW), RB211-524H8 (RR).

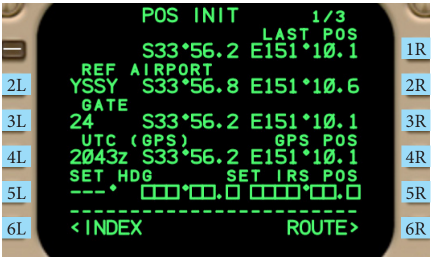
2R ACTIVE
Shows the time range and year of the active navigation database. (When the range ends in January, the year after the slash refers to January.)

3R Inactive database
Shows the time range and year of the inactive navigation database. Can be swapped with the active database by downselecting 3R and upselecting it to 2R. The exchange clears all routes and the fix info. *(In the simulator, when the aircraft is parked, a virtual engineer may load and select the database suitable to the currently modeled time of the year; refer to **Instructor > Situation > Service: FMS services**.)*

4R CO DATA
Shows the company policy file identifier.

6R POS INIT>
Opens the POS INIT 1/3 page.

POS INIT 1/3 Page:



Access:
- INIT REF when on ground and IRS not aligned and IRS position not entered
- 6R on IDENT
- 2L on INIT/REF INDEX

General:
Displays information regarding IRS alignment and FMC time reference.

2L REF AIRPORT
When database airport is entered, shows airport reference coordinates in 2R, and allows entry of gate in 3L. Deletion also deletes 3L and 3R. Blank when airborne.

Valid entries
4-letter ICAO code of database airport.

3L GATE
When gate is entered, shows gate coordinates in 3R. Blank when airborne.

Valid entries
Gate in database (1 to 5 characters).

4L UTC
Shows time reference used by FMC. Line title indicates GPS when FMC uses GPS time; or MAN when FMC uses manual settings from captain's clock or, if that fails, from first officer's clock. Blank if clocks fail.

5L SET HDG
Entry sets heading in every IRU that is in ATT mode. Blank if no IRU in ATT mode.

Valid entries
Heading (000 to 360):
XXX

6L <INDEX
Opens the INIT/REF INDEX page.

1R LAST POS
Shows last, FMC computed aircraft position. Can be downselected for upselection to 5R.

2R Airport reference location
Indicated when an airport is entered in 2L. Can be downselected for upselection to 5R.

3R Gate location
Indicated when a gate is entered in 3L. Can be downselected for upselection to 5R.

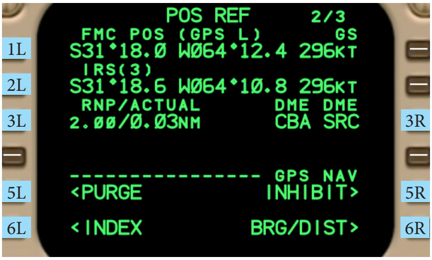
4R GPS computed aircraft position
Indicated when GPS is available. Can be downselected for upselection to 5R.

5R SET IRS POS
Entry sets position in every IRU that is aligning. Blank when no IRU is aligning. Boxed when entry is required.

Valid entries
Coordinates, for example:
For N27° 59.7' E086° 55.8'
enter N2759.7E08655.8

6R ROUTE>
Opens the RTE page.

POS REF 2/3 Page:



Access:

- 2L on INIT/REF INDEX, then NEXT if on ground or if any IRU in ATT mode.
- 6R on PROGRESS 1/3.

General:

Provides functions to control the data sources and the precision of the FMC position calculation.

1L FMC POS

Shows current aircraft position and ground speed calculated by the FMC. Position can be downselected. Line title indicates position update mode. Possible modes are: GPS L, GPS R, LOC GPS L, LOC GPS R, LOC DD, LOC VD, LOC, RADIO, IRS L, IRS R, IRS C, IRS 3.

2L IRS

Shows current aircraft position and ground speed based on IRS only. Can be downselected. Line title indicates data source which may be L, C, R, or 3. (The FMC uses either a single IRU or all three IRUs.) Blank when no IRU data available.

3L RNP/ACTUAL

Shows required navigation performance (RNP) for active leg, as default in small font; or a manual entry in large font. Deletion returns to default. Shows after the slash the actual navigation performance (ANP).

Valid entries RNP value (0.01 to 99.9): X X.X X.XX XX XX.X

5L <PURGE

When selected, displays <CONFIRM. When confirmed, radio and GPS position corrections are purged so that the FMC position is equal to the mixed IRS position. Then, as soon as radios or GPS are available, the FMC will reintroduce radio or GPS position corrections. <CONFIRM key is reset when both CDUs are not on this page.

6L <INDEX

Opens the INIT/REF INDEX page.

3R Navigation stations

Shows identifiers of stations currently used for position calculation. Blank if no station available. Line title may read DME DME, VOR DME, or NAV STA.

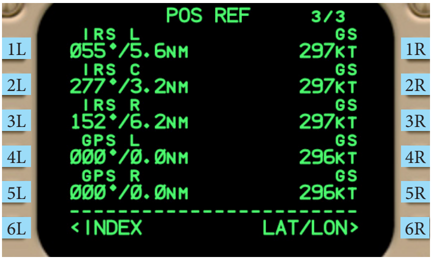
5R GPS NAV

When GPS is enabled, displays INHIBIT>. When GPS is inhibited, displays ENABLE>. Selection accordingly inhibits or enables GPS position updating.

6R Position display format

Key reads BRG/DIST> or LAT/LON>. Selected format is applied to all position indications on POS REF 2/3 and POS REF 3/3. When both CDUs are not on these pages, format returns to latitude/longitude.

POS REF 3/3 Page:



Access:
2L on INIT/REF INDEX; then PREV if on ground or any IRU in ATT mode, otherwise NEXT.

General:
Indicates aircraft position and ground speed calculations of each IRU and each GPS unit.

1L 2L 3L 4L 5L **Position indication**
Shows current aircraft position calculated by the respective unit. Can be downselected. Blank when the respective unit is not available or inhibited.

1R 2R 3R 4R 5R **Ground speed indication**
Shows current ground speed calculated by the respective unit. Blank when the respective unit is not available or inhibited.

6L **<INDEX**
Opens the INIT/REF INDEX page.

6R **Position display format**
Key reads BRG/DIST> or LAT/LON>. Selected format is applied to all position indications on POS REF 2/3 and POS REF 3/3. When both CDUs are not on these pages, format returns to latitude/longitude. The bearing/distance format indicates the bearing and distance from the FMC computed aircraft position to the aircraft position computed by the respective unit.

PERF INIT Page:

Access:
- INIT REF when on ground and IRS set, and PERF INIT 1L, 4L, 5L, 1R not set.
- 6R on RTE.
- 3L on INIT/REF INDEX.

General:
Provides functions to initialize FMC performance calculations.

1L GR WT DUAL

Displays the current gross weight when entered or calculated.

A If a weight & balance system (WBS) is installed and operative, a WBS computed gross weight is displayed in small font. A caret is shown until a value is entered or confirmed. Deletion resets it to the WBS computed value. If two weight & balance computers (WBCs) are installed and operative, line title indicates DUAL (reliable mode). If a single WBC is installed and operative, line title indicates ADV (advisory only). Otherwise, boxes are displayed instead of a small-font value, and deletion is not allowed.

Valid entries
Weight in 1L minus weight in 2L must result in a ZFW in the range of 179.5 to 270.0 kg x 1000 (395.7 to 595.2 lb x 1000):
XXX
XXX.X

2L FUEL

Displays fuel weight; boxed when data from FQIS is invalid. Indicates CALC when FMC calculated value is shown; SENSED when FQIS value is shown; MANUAL when crew entry is shown; deletion resets to CALC mode. When CALC mode is unavailable (for example, because all three EIUs failed), system switches to SENSED mode after a delay of 2 minutes. In SENSED mode, manual entries are inhibited.

Valid entries
Weight x 1000 (0 to aircraft specific limit):
X
XX
XXX
X.X
XX.X
XXX.X

3L ZFW

Displays zero fuel weight (ZFW). Indicated in small font when ZFW is automatically computed, based on entries in 1L and 2L.

Valid entries
Weight (180.0 to 270.0 kg x 1000, or 396.9 to 595.2 lb x 1000):
XXX
XXX.X

(continued next page)

PERF INIT Page: *(continued)*

4L RESERVES
Displays fuel reserves for INSUFFICIENT FUEL message trigger. When boxed, the system will trigger at 5000 kg (11000 lb).

Valid entries
Weight (0 to 108.9 kg or 240.0 lb x 1000):
X
XX
XXX
X.X
XX.X
XXX.X

4L COST INDEX
Displays the cost index for VNAV ECON speed calculation. Index zero sets maximum range speed for minimum trip fuel. The higher the index, the higher the speed. Tailwind, altitude and other variables influence the ECON speed as well. Increase the index when *flight time* is expensive, decrease it when *fuel* is expensive.

Valid entries
Cost index (0 to 9999):
X
XX
XXX
XXXX

6L <INDEX
Opens the INIT/REF INDEX page.

1R CRZ ALT
Displays the VNAV cruise altitude. May be entered also on VNAV CLB and CRZ pages, followed by activation by EXEC key. Entry on PERF INIT page requires no activation, but is only allowed when on the ground.

Valid entries
Altitude (-1005 to 45100):
XXX
XXXX
XXXXX
FLXXX

3R A BALLAST *(on combi aircraft)*
Displays the fuel ballast limit for >FUEL BALLAST caution message trigger. Combi aircraft may be tail-heavy, requiring a counter weight (ballast) in the forward section of the aircraft. When the message appears, the crew turns off the center tank pumps to use the remaining center tank fuel (located in the forward section) as ballast. Ballast fuel is also indicated on the EICAS.

Valid entries
Weight (0 to 45.3 kg or 99.9 lb x 1000):
X
XX
X.X
XX.X

(continued next page)

PERF INIT Page: *(continued)*

4R **CRZ CG**

Displays the center of gravity for cruise; in small font the default, in large font manual entries. Value influences the computation of maneuver margin to buffet and maximum altitude.

Valid entries
Percent (8.5 to 33.0):
X
XX
X.X
XX.X

5R **STEP SIZE**

Displays the step size used for VNAV cruise step climb computations. No step climb will occur when zero is entered. Default entry is ICAO which applies ICAO flight level separation rules for step sizes.

Valid entries
Increments of 1000 (0 to 9000), or ICAO:
0
X000
ICAO
I

6R **THRUST LIM>**

Opens the THRUST LIM page.

THRUST LIM Page – on Ground:

Access:
- 6R on TAKEOFF REF if preflight done
- 6R on PERF INIT
- 4L on INIT/REF INDEX

General:
Allows selection of takeoff thrust limit and arming of climb thrust limit.

1L **SEL**
Shows pilot entered assumed temperature. Function can be used to make the FMC "assume" the OAT is higher than sensed, so that the FMC may compute a more economic, lower (derated) takeoff thrust. Entries are automatically limited to 63°C (145°F). Computed result will appear circa 5 seconds after entry. If entered temperature is high enough to result in a derated thrust, D-TO will be indicated in 1R and on the primary EICAS display. Line deletion clears the derate. Derates may cause the <ARM> flag to move from CLB to CLB 1 or 2.

Valid entries
Temperature (0° to 99°C, or 32° to 210°F):
X
XX
XXF
XXXF

1R **Takeoff thrust limit**
Shows selected takeoff thrust limit. Line title indicates selected mode. Sensed OAT from ADCs is displayed in the middle of the line.
A Thrust limit is indicated by EPR *(PW and RR engines)* or by N1 *(GE engines)*.

A TO 1 and TO 2 selections may be unavailable as per option programming.

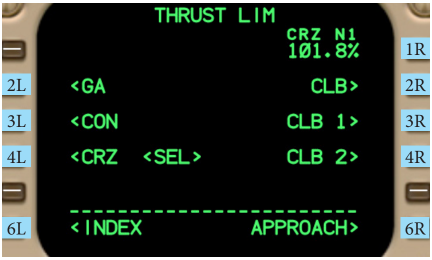
2L 3L 4L **<TO TO 1 TO 2**
Selects respective takeoff thrust limit. TO is full rated thrust, TO 1 and 2 are fixed thrust derates. Selection also arms the associated CLB thrust derate.
A The percentage is engine model specific.

2R 3R 4R **CLB> CLB 1> CLB 2>**
Arms respective climb thrust limit which will automatically activate at the thrust reduction point set in 3R on TAKEOFF REF page. CLB is full climb thrust, CLB 1 and 2 are fixed thrust derates.

6L **<INDEX**
Opens the INIT/REF INDEX page.

6R **TAKEOFF>**
Opens the TAKEOFF REF page.

THRUST LIM Page – in Flight:



Access:
- 6R on TAKEOFF REF
- 6R on PERF INIT
- 4L on INIT/REF INDEX

General:
Provides thrust limit selection for all flight phases other than takeoff phase.

1R Thrust limit
Shows selected thrust limit. Line title indicates selected mode.

A Thrust limit is indicated by EPR *(PW and RR engines)* or by N1 *(GE engines)*.

2L <GA
Activates go-around thrust limit. Autoselected when flaps are out in cruise or descent, or when G/S mode is engaged.

3L <CON
Activates maximum continuous thrust limit. Automatically selected when engine out is detected during takeoff and airspeed rises above VREF+98.

4L <CRZ
Activates cruise thrust limit. Automatically selected when reaching cruise altitude and if automatic CRZ thrust limit selection is enabled on PERF FACTORS page.

2R 3R 4R CLB> CLB 1> CLB 2>
Activates respective climb thrust limit. CLB is full climb thrust, CLB 1 and 2 are fixed thrust derates.

A Derates are gradually washed out when climbing above 10000 ft, and are fully removed above 15000 ft.

A Derates are gradually washed out when climbing above 25000 ft, and are fully removed above 35000 ft for CLB 1 and above 38800 ft for CLB 2.

6L <INDEX
Opens the INIT/REF INDEX page.

6R APPROACH>
Opens the APPROACH REF page.

TAKEOFF REF Page:

Access:
- INIT REF when on ground and IRS set, and PERF INIT 1L, 4L, 5L, 1R set.
- 6R on THRUST LIM.
- 5L on INIT/REF INDEX.

General:
Note: All heights are barometric (above elevation recorded when passing 100 kt).

1L FLAP/ACCEL HT
Shows planned takeoff flap setting, and VNAV acceleration height where flap retraction begins. Flap entry is boxed when no manual entry exists. Acceleration height default value from PERF FACTORS page is displayed in small font when the height is not entered manually. Deletion sets default.

Valid entries
Flap (10 or 20):
X0
Height (400 to 9999):
XXX
XXXX
/XXX
/XXXX
Flap/height:
X0/XXX
X0/XXXX

2L E/O ACCEL HT
Shows VNAV acceleration height for flap retraction in case of engine failure. Shows default value from PERF FACTORS page in small font when no manual entry exists.

Valid entries
Height (400 to 9999):
XXX
XXXX

3L THR REDUCTION
Displays trigger that will reduce takeoff thrust limit to armed climb thrust limit; this will occur either when flaps are set to 5, or when passing a height. Also shows armed climb thrust limit (CLB, CLB1, or CLB2).

Valid entries
Flaps 5:
5
Height (400 to 9999):
XXX
XXXX

4L WIND/SLOPE
Shows takeoff headwind (H) or tailwind (T), and runway upslope (U) or downslope (D). Deletion returns to H00/U0.0 in small font. Data are used for V speed computations.

Valid entries
Wind (T0 to T99, or H0 to H99):
TX
HXX
Slope (D0 to D2.0, or U0 to U2.0):
/DX
/UX.X
Wind/slope:
HX/DX.X

(continued next page)

TAKEOFF REF Page: *(continued)*

5L RWY COND
Shows runway condition. Data is used for V speed computations.

Valid entries
W or WET; D or DRY.

6L <INDEX
Opens the INIT/REF INDEX page.

1R 2R 3R V1 VR V2
Shows V speed for reference in warning systems and for display on PFDs (requires large-font V speed entries). Line title is preceded by REF when FMC computed speed is displayed in small font (for this function, runway entry must exist on first RTE page). MIN is indicated when too low a manual entry is reset to the allowable minimum. Computation takes into account the flap setting, wind, slope, runway condition, takeoff thrust limit, gross weight, OAT, and pressure altitude. Changes to these data will also change the V speeds. Before the third engine is started, manual V speed entries are reset when a gross weight, OAT, or pressure altitude change causes a difference of 2 kt or more.

Valid entries
Speed (100 to 300):
XXX

4R TRIM CG
Displays required stabilizer trim for takeoff when a center of gravity (CG) value is entered. Trim display will appear circa 5 seconds after CG entry.

If a weight & balance system (WBS) is installed and operative, the WBS detected CG is displayed in small font.

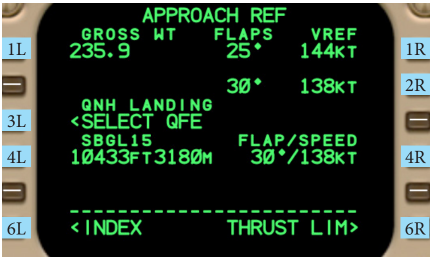
Valid entries
Center of gravity (0 to 40):
X
XX

5R POS SHIFT
Shows runway identifier, and takeoff position shift relative to landing threshold (runway coordinates in database refer to landing thresholds). Negative values indicate the takeoff position is in front of the landing threshold (longer takeoff runway), positive values indicate it is past the landing threshold (shorter takeoff runway). When TOGA switch is pushed, IRS computed aircraft position is reset to landing threshold location stored in database. If aircraft takeoff position is not equal to landing threshold location, entered position shift will correct that IRS resetting.

Valid entries ***in meters or feet***
(-30 to +30 meters, or -99 to +99 ft) x 100:
-X
-XX
+X
+XX

6R Preflight page
Depending on completed preflight steps, opens the POS INIT, the ROUTE, the PERF INIT, or the THRUST LIM page.

APPROACH REF Page:



Access:
- INIT REF when in VNAV CRZ or DES
- 6R on THRUST LIM when in flight
- 6L on INIT/REF INDEX

General:
Provides approach reference data indications and functions.

1L GROSS WT
When page is opened, initially shows gross weight from PERF INIT page, or boxes when data is unavailable. Entering a gross weight in 1L will not change PERF INIT settings; the gross weight in 1L is solely used to compute and display respective VREF speeds in 1R and 2R.

Valid entries
Weight (within aircraft specific range):
XXX
XXX.X

3L Touchdown zone reference
When QFE landing mode is selected, PFD touchdown zone is set to 0 ft, and a green QFE flag is shown under the altimeter tape. In QNH mode (normal mode), touchdown zone is set to landing threshold elevation.

4L Runway data
Line title shows airport identifier followed by runway identifier. Runway length is indicated in feet and meters. Data refer to departure runway as long as aircraft is less than halfway to the destination and within 400 nm of origin. Otherwise, data refer to destination runway.

6L <INDEX
Opens the INIT/REF INDEX page.

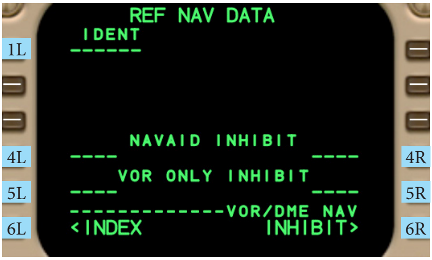
1R 2R VREF
Shows computed VREF for flaps 25 and 30. Can be downselected for upselection to 4R. When both CDUs are not on this page, manually entered gross weight in 1L and associated VREF speeds in 1R and 2R are reset to FMC computed gross weight reference.

4R FLAP/SPEED
Indicates planned landing flaps and selected reference speed. Reference sets VREF marker and flap speed markers on PFDs.

Valid entries
Speed (100 to 250):
XXX
/XXX
Flap/speed:
0/XXX
1/XXX
5/XXX
10/XXX
20/XXX
25/XXX
30/XXX

6R THRUST LIM>
Opens the THRUST LIM page.

REF NAV DATA Page:



Access:
1R on INIT/REF INDEX

General:
Displays data from navigation database and active route, and allows the crew to inhibit specific navigation radios. All inhibits are reset at flight completion.

1L IDENT

When the page is opened, initially displays dashes. When a valid identifier is entered, the upper half of the page will display waypoint type specific data.

Valid entries
Identifier of any waypoint, navaid, airport, or destination runway in the database or in the active route.

4L 4R NAVAID INHIBIT

Allows entry of up to two VOR, DME, VORDME, or VORTAC identifiers. Entered stations will not be autotuned by FMC and will not be used for radio updating.

Valid entries
Identifier (1 to 3 letters).

5L 5R VOR ONLY INHIBIT

Allows entry of up to two VOR, VORDME, or VORTAC identifiers. For radio updating, the FMC will not use the VOR part of the entered stations but just the DME part.

Valid entries
Identifier (1 to 3 letters).

6L <INDEX

Opens the INIT/REF INDEX page.

6R VOR/DME NAV INHIBIT>

When selected, 5L and 5R indicate ALL, and FMC will not use VOR/DME combinations for radio updating. DME/DME combinations remain enabled. Also, when 6R is selected, key reads ENABLE>, allowing the crew to clear the inhibit.

MAINTENANCE INDEX Page:

Access:
6R on INIT/REF INDEX

General:
Displays an index of all maintenance pages. Access is inhibited when airborne.

1L **<CROSS LOAD**
Opens the NAV DATA CROSSLOAD page.

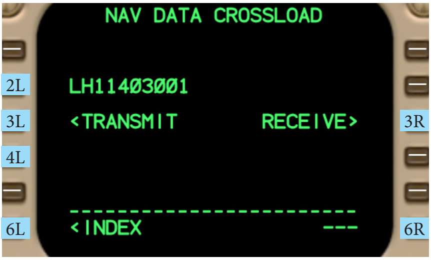
1R **BITE>**
Opens the FMC (L or R) BITE REPORT page.

2L **<PERF FACTORS**
Opens the PERF FACTORS page.

3L **<IRS MONITOR**
Opens the IRS MONITOR page.

6L **<INDEX**
Opens the INIT/REF INDEX page.

NAV DATA CROSSLOAD Page:



Access:

- 1L on MAINTENANCE INDEX
- Automatically displayed when database disagreement detected between FMCs

General:

Allows authorized engineers to copy a navigation database from one FMC to the other.

2L Navigation database identifier

Shows the identifier of the navigation database in the respective onside FMC (FMC L or R, as per the onside NAV source selection). The order of the characters: 1 & 2 identify the airline, 3 the database number, 4 & 5 the production year, 6 & 7 the cycle number, and 8 to 10 the sequence number.

3L <TRANSMIT

Selection blanks the RECEIVE> key and enables the respective FMC (L or R, linked with this CDU) to be the transmitter during the crossload.

4L Crossload status message

- TRANSFER IN PROGRESS is indicated during the transfer.
- TRANSFER COMPLETE is indicated when the database is successfully transferred.
- TRANSFER ABORTED is indicated when a fault occurred.

6L <INDEX

Opens the MAINTENANCE INDEX page.

3R RECEIVE>

Selection blanks the <TRANSMIT key and enables the respective FMC (L or R, linked with this CDU) to be the receiver. When one FMC is the transmitter, and the other is the receiver, the transfer starts: the receiver's CDU will open the MENU page; there will be no access to the pages of the receiver FMC during the transfer. The transfer takes circa 5 minutes. *(In the simulator, the time can be shortened by the time acceleration slider on **Instructor** > **Situation** > **Time**.)*

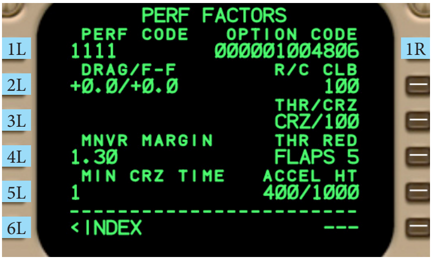
6R Arm key

Arms the functions in 3L and 3R. Leaving this page will disarm them.

Valid entry

ARM

PERF FACTORS Page:



Access:
2L on MAINTENANCE INDEX

General:
Allows authorized engineers to set default values for various FMC functions.

1L PERF CODE
Shows pin-programmed performance code.

2L DRAG/F-F
Displays the correction factors in percent for aerodynamic drag and engine fuel flow. The FMC will apply these factors in its aircraft performance predictions.
(In the simulator, to assure accurate FMC operation, the physical drag and fuel flow factors entered on ***Instructor*** *>* ***Model*** *>* ***Airframe*** *are automatically copied to the factors here on the FMC's PERF FACTORS page. Once they are copied, the factors here in the FMC can be changed without being copied back to the physical factors on the Instructor. Such modifications in the FMC may be used for system demonstrations only; disagreements between physical factors and FMC factors cause inaccurate predictions.)*

Valid entries
Drag factor (-9.9 to +9.9):
-X.X
X.X
Fuel flow factor (-9.9 to +9.9):
/-X.X
/X.X
Drag factor/fuel flow factor:
X.X/X.X

4L MNVR MARGIN
Shows maneuver margin that the FMC uses for bank limit and flight envelope calculations. FAA permitted range is 1.20 to 1.30, CAA (JAR) permits 1.30 only.
(In the simulator, FAA range may be applied on all aircraft.)

Valid entries
Margin (1.20 to 1.30):
X.X
X.XX

5L MIN CRZ TIME
Shows minimum cruise time that the FMC applies in its computation of the optimum altitude on short trips.

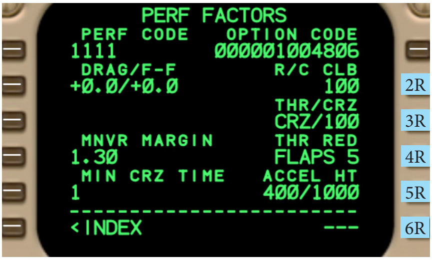
Valid entries
Minutes (1 to 20):
X
XX

6L <INDEX
Opens the MAINTENANCE INDEX page.

1R OPTION CODE
Shows the code of the authorized option configuration.

(continued next page)

PERF FACTORS Page: *(continued)*



2R R/C CLB

Displays the desired minimum residual rate of climb which the FMC takes into account in its calculation of the optimum altitudes with reference to climb speed and CLB thrust limit.

Valid entries
Feet per minute (0 to 500):
X
XX
XXX

3R THR/CRZ

Displays CRZ or CLB before slash. If CRZ is entered, FMC will switch thrust limit mode from CLB to CRZ when reaching cruise altitude. After slash, indicates the desired minimum residual rate of climb which the FMC takes into account in its calculation of the optimum altitudes with reference to cruise speed and thrust limit entered in 3R.

Valid entries
Thrust limit mode (CLB or CRZ):
XXX/
Feet per minute (0 to 500):
X
XX
XXX
Thrust limit mode/feet per minute:
XXX/XXX

4R THR RED

Shows the default thrust reduction trigger used on the TAKEOFF REF page in 3L.

Valid entries
Flaps 5:
5
Height (400 to 9999):
XXX
XXXX

5R ACCEL HT

Shows the default engine-out and all-engines acceleration heights used on the TAKEOFF REF page in 2L and 1L.

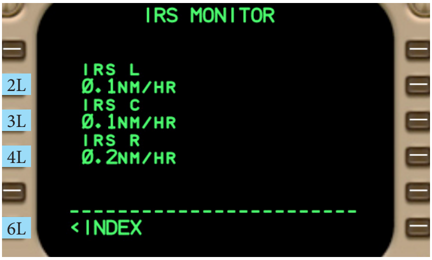
Valid entries
e/o accel height/all-eng accel height:
XXX/XXX
XXX/XXXX
XXXX/XXXX

6R Arm key

Enables data entries on this page. Leaving this page will disable them.

Valid entry
ARM

IRS MONITOR Page:



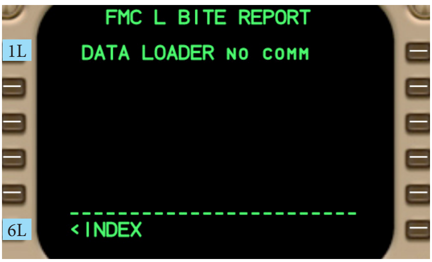
Access:
3L on MAINTENANCE INDEX

General:
Displays IRS position error rates relative to FMC position. Used for evaluation after flight completion. Indications are removed and reset at next lift-off.

2L 3L 4L **IRS L IRS C IRS R**
Indicates after flight completion the average position drift of IRU L, C, and R in nautical miles per hour. The values are based on the last recorded total flight time and the current distance between the respective *IRU* computed aircraft position and the *FMC* computed aircraft position (as the FMC uses GPS and radio updating, it provides the most accurate aircraft position).

6L **<INDEX**
Opens the MAINTENANCE INDEX page.

FMC BITE REPORT Page:



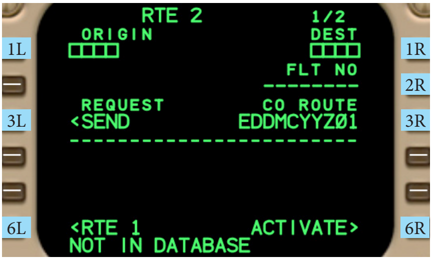
Access:
1R on MAINTENANCE INDEX

General:
Displays information from the FMC's built-in test equipment (BITE). The onside CDU shows information of the respective FMC—L or R, as per the onside selected NAV source.

1L **Status**
(In the simulator, the status remains NO COMM in all situations.)

6L **<INDEX**
Opens the MAINTENANCE INDEX page.

RTE Page:



Access:
- 6R on POS INIT 1/3
- 6R on ARRIVALS or DEPARTURES
- 1L on FMC COMM 1/2
- RTE key opens ACT RTE or RTE 1
- 6L on one RTE opens the other RTE

General: Provides functions to initialize and modify the flight plan routes.

1L ORIGIN

Shows origin airport. Entry deletes current route. Entry is inhibited for active route when airborne.

Valid entries
ICAO identifier in database:
XXXX

3L <SEND

May be selected if an identifier entered in 3R refers to a company route that is not in the on-board database. That is, when <SEND is selected, a downlink route request (down to the ground station) is initiated and SENDING will be displayed. When receipt is acknowledged, <SENDSENT will be displayed. Blanks when route uplink is ready, which may take 30 seconds or more *(in the simulator, the time can be accelerated on **Instructor** > **Situation** > **Time**)*. In case of a fault, line title reads DATA LINK and key reads FAIL (ACARS fault), NO COMM (radio or FMC fault), or VOICE (radio not on ACARS frequency).

6L <RTE 1 or <RTE 2 or <ERASE

Opens the RTE page of the other route. When the page shows a modified route, the key reads <ERASE which allows the crew to cancel the modification.

1R DEST

Shows destination airport. Entry deletes current arrival procedures.

Valid entries
ICAO identifier in database:
XXXX

2R FLT NO

Shows flight number.

Valid entries
Any entry (1 to 10 characters).

3R CO ROUTE

Allows entry of a company route identifier. Entry is inhibited for active route when airborne. If desired route is in database, data loading starts immediately and will be completed after circa 10 seconds. If route is not in on-board database, route may be requested from dispatch (refer to 3L). *(In the simulator, the database status of a route can be set on **Instructor** > **Situation** > **Human** > **Dispatcher** with the checkbox **Requires route uplink**.)*

Valid entries
Any entry (1 to 10 characters).

6R ACTIVATE> or PERF INIT>

If the route is inactive, arms it for activation, otherwise opens the PERF INIT page.

(continued next page)

RTE Page: *(continued)*

When a requested route uplink is valid and ready to be loaded, ROUTE UPLINK is indicated in small font in the middle of the page.

4L <LOAD

Shown when a requested route uplink is valid and ready to be loaded into the FMC. Selection will start the loading process which will be completed after circa 10 seconds. Selection also blanks PURGE> key.

4R PURGE>

Shown when a requested route uplink is valid and ready to be loaded into the *inactive* RTE page. Selection will purge the uplinked data; that is, the data will not be loaded into the FMC.

When the ACTIVATE> key is selected, and at least one leg exists in the route, and the EXEC key is pushed, the route becomes active and ACT will be displayed in the page title.

2L RUNWAY

Shows departure runway loaded by company route, by manual entry, or by departure procedure selection.

Valid entries

Identifier of departure runway:

X
XX
XXX
RWX
RWXX
RWXXX

5L <RTE COPY

Only available on the active RTE page. Copies the active route to the inactive route on the other RTE page. The previous inactive route will be overwritten.

5R CO REPORT SEND>

Sends a route report to dispatch.

(continued next page)

RTE Page: *(continued)*

The flight plan route starts on page 2. It can be entered in ATC clearance language; that is, multiple subsequent legs lying on the same airway or procedure may be grouped to a single VIA-TO expression. —The waypoints under TO cannot be deleted or overwritten on these pages; this is only allowed on the LEGS pages.

1L 2L 3L 4L 5L **VIA**

In the first line, shows the airway or procedure starting at the current aircraft position, leading to the TO fix displayed in the same line. In the following lines, each VIA segment starts at the TO fix of the respective previous line.—Displays dashes at the route end or in a route discontinuity.—Procedures cannot be entered here; they are automatically entered when the crew selects procedures on the DEPARTURES and ARRIVALS pages.—A transition procedure is indicated by its transition fix and by the procedure it is connected with, separated by a dot, for example:

via **CAX.NDB28** – to CN28

CAX is the fix of the transition, and the transition is connected with the NDB28 approach which starts at CN28.

Valid entries

Direct to the fix displayed under TO:
 DIRECT

An airway connecting the previous TO fix and, if already entered, the next TO fix:
 XX
 XXX
 XXXX
 XXXXX

For special entries, refer to the next two pages in this chapter.

1R 2R 3R 4R 5R **TO**

Shows the fix that exits the airway or procedure segment entered in the same line under VIA, and that also connects to the next VIA entry. Displays dashes at the end of the route; displays boxes in a route discontinuity, or after a VIA entry whose associated TO fix is not entered yet. Entries are only allowed where dashes or boxes are displayed.

Valid entries

Any waypoint, station, or airport identifier in the database or route; or coordinates, for example:
 For N27° 59.7’ E086° 55.8’
  enter N2759.7E08655.8
 For N27° 00.0’ E086° 00.0’
  enter N27E086

One destination runway, for example:
 For runway 07 enter RW07 or 07.

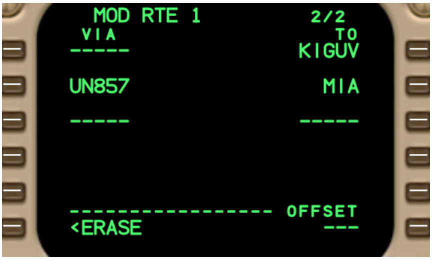
Place-bearing/distance, for example:
 For 5 nm from JFK on 090° bearing
  enter JFK090/5

Place-bearing/place-bearing, for example:
 For the intersection of JFK bearing 270° with LGA bearing 180°
  enter JFK270/LGA180

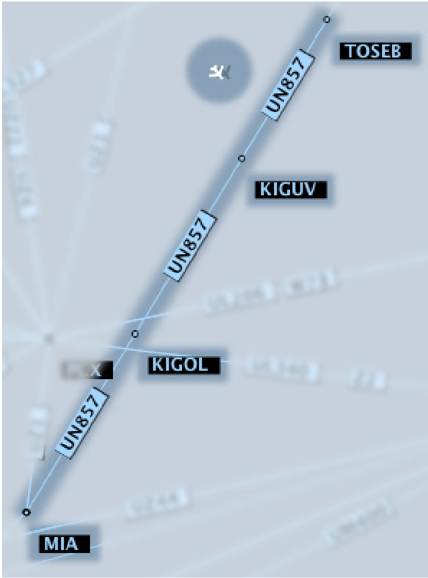
(continued next page)

RTE Page: *(continued)*

If the initial fix of the first VIA entry is not defined yet, but just the exit point of it, enter that exit point in 1R; in this example, MIA. Then enter the desired airway (which leads to MIA) in 1L. In this example, enter UN857 in 1L.



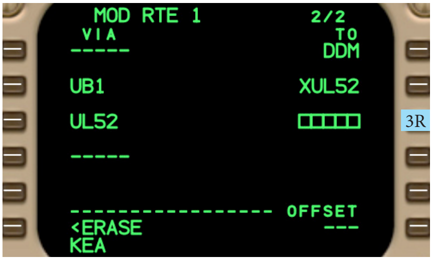
The FMC checks which fix on UN857 is the nearest to the current aircraft position; in this example, KIGUV. The FMC moves UN857 and MIA one line further down, and automatically inserts KIGUV in 1R.



(continued next page)

RTE Page: *(continued)*

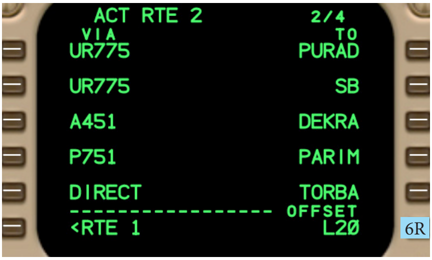
To find an airway-to-airway intersection —in this example, an intersection between UB1 and UL52—, enter UB1 in 2L, and UL52 in 3L. The FMC will search for the nearest airway-to-airway intersection.



When the FMC has found an intersection, but a database waypoint does not exist there, the FMC will create a new one; in this example, named XUL52 (the identifier of the next airway preceded by X). —To complete this function, enter the desired exit point of UL52 in the adjacent boxes; in this example, KEA in 3R.

(continued next page)

RTE Page: *(continued)*



6R **OFFSET**

Constructs a parallel offset route for weather avoidance or traffic separation. Data entry is not allowed and PERF INIT> is displayed when any of the following is true:

- Aircraft is on the ground.
- Active leg is part of a procedure.
- Route is inactive.

Otherwise, dashes are initially displayed. When an offset value is entered, the offset route starts parallel to the active leg and ends at any of the following points, whichever occurs first:

- Waypoint of a procedure.
- Route discontinuity.
- Holding pattern.
- Leg course change greater than 135°.

LNAV will guide along the offset route.

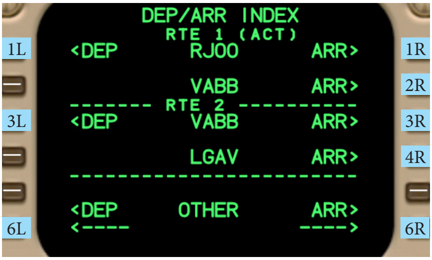
—The offset can be removed by entering 0 in 6R, or by deleting 6R, or by entering a direct-to waypoint in the first line on the first LEGS page.

Valid entries

Distance (0 to 99 nm left or right), or zero:

LX
LXX
RX
RXX
0

DEP/ARR INDEX Page:



Access:
- DEP ARR key if no active route exists
- 6L on ARRIVALS if route not modified
- 6L on DEPARTURES if not modified

General: Provides access to various DEPARTURES and ARRIVALS pages. The titles in the middle of the lines 1 and 3 indicate ACT for the active route.

1L <DEP RTE 1
Opens the DEPARTURES page for the origin airport of route 1.

3L <DEP RTE 2
Opens the DEPARTURES page for the origin airport of route 2.

6L <DEP OTHER
Opens a DEPARTURES page (for review only) for the airport entered in the dashes.

Valid entries
Airport ICAO identifier in database: XXXX

1R ARR> RTE 1 (origin)
Opens the ARRIVALS page for the origin airport of route 1.

2R ARR> RTE 1 (destination)
Opens the ARRIVALS page for the destination airport of route 1.

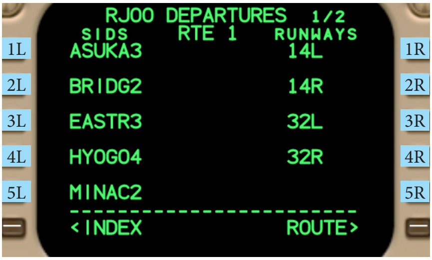
3R ARR> RTE 2 (origin)
Opens the ARRIVALS page for the origin airport of route 2.

4R ARR> RTE 2 (destination)
Opens the ARRIVALS page for the destination airport of route 2.

6R ARR> OTHER
Opens an ARRIVALS page (for review only) for the airport entered in the dashes.

Valid entries
Airport ICAO identifier in database: XXXX

DEPARTURES Page (Active Route):



Access:
- DEP ARR key if on ground and active route exists
- 1L on DEP/ARR INDEX (for RTE 1)
- 3L on DEP/ARR INDEX (for RTE 2)

General: Allows selection of a runway, a standard instrument departure (SID), and an enroute transition if required.

1L 2L 3L 4L 5L **SIDS**

Selects a SID for the airport displayed in the page title. Multiple pages are created if more than 5 SIDs are listed. If a runway is selected first, only SIDs are listed that are compatible with that runway.

1R 2R 3R 4R 5R **RUNWAYS**

Selects a departure runway for the airport displayed in the page title. Multiple pages are created if more than 5 runways are listed. If a SID is selected first, only runways are listed that are compatible with that SID.

Selection process – example:

When 32L is selected, select HYOGO4.

Select TOZAN enroute transition.

Activate selections by pushing EXEC key.

<SEL> flags are changed to <ACT>.

ARRIVALS Page (Active Route):

Access:
- DEP ARR key if in flight and active route exists.
- 1R, 2R, 3R, or 4R on DEP/ARR INDEX for the respective airport.

General: Allows selection of an approach, a standard terminal arrival route (STAR), and transitions if required.

1L 2L 3L 4L 5L **STARS**

Selects a STAR for the airport displayed in the page title. Multiple pages are created if more than 5 STARs are listed. If an approach is selected first, only STARs are listed that are compatible with that approach.

1R 2R 3R 4R 5R **APPROACHES**

Selects approach. Multiple pages are created if more than 5 approaches are listed. If a STAR is selected first, only approaches are listed that are compatible with that STAR. Third letters may identify different approaches to the same runway; for example, ILY27 & ILZ27 are ILS-Y & ILS-Z.

Selection process – example:

Select ILS14 and BBB approach transition.

Then select POKO1C.

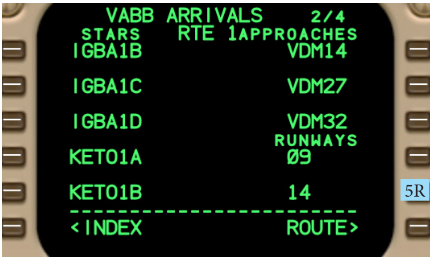
Select BOMBA enroute transition.

Activate selections by pushing EXEC key.

(continued next page)

ARRIVALS Page (Active Route): *(continued)*

VFR approach selection – example:



Press the NEXT PAGE key repeatedly until the RUNWAYS list appears. To create a VFR approach to runway 14, select runway 14 under RUNWAYS in line 5R.

In line 3R, a distance from the runway can be entered **(valid entry is 1.0 to 25.0 nm)**; the FMC will create a fix at that distance on the extended runway centerline for LNAV guidance. When the VFR APPR> key in 2R is selected, the distance is set to the default value of 8 nm. Entries in 3R are only allowed when dashes are displayed.

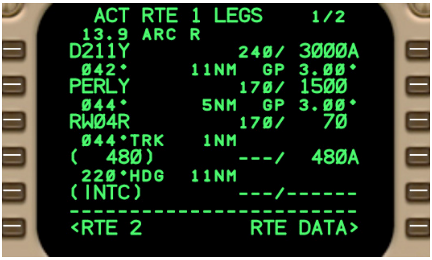
When a distance is entered in line 3R, line 4R allows the crew to adjust the vertical flight path angle (FPA) for the final approach **(valid entry is 2.4° to 3.7°)**. Initially displays the default of 3.0°. When all is set as desired, activate the selections by pushing the EXEC key.

(continued next page)

ARRIVALS Page (Active Route): *(continued)*

6R **INTC>**
Replaces the ROUTE> key when an approach is selected in flight for the active route. When selected, opens the first LEGS page, and automatically moves the approach intercept fix—in this example, the CI14 waypoint—up to the first LEGS line. That is, CI14 will be the active waypoint, and the inbound course to CI14 will be equal to the approach course; here, equal to the course of the ILS14 approach.

LEGS Page:



Access:
- LEGS key
- 6L on RTE DATA

General:
Provides tools to build and modify route legs for lateral and vertical guidance.

Leg line titles (all in small font)
Each line title on the *left-hand* side indicates the respective leg type, for example:

13.9 ARC R Aircraft follows a right-turn DME arc at radius 13.9 nm.

042° Aircraft follows a 042° course of an airway or of any other geographically fixed, lateral path.

044°TRK Aircraft flies a track of 044° (without course correction).

220°HDG Aircraft flies a constant heading of 220° (not a course).

---° Undefined direction.

PROC TURN Procedure turn.

HOLD AT Holding pattern.

A course, heading, or track refers to true north when the indication has a T-suffix, otherwise it refers to magnetic north.

In the *middle* of the page, the line title indicates the computed length of the leg if applicable, or ROUTE DISCONTINUITY if there is a gap.

The line title on the *right-hand* side indicates the glide path (GP) angle if the leg belongs to a final approach; for example, GP 3.00°.

Leg lines
The *left-hand* side indicates in large font how a leg will be terminated, for example:

PERLY Identifier of a geographically fixed waypoint; the leg terminates when the aircraft flies by or over this waypoint.

(480) Conditional waypoint; the leg terminates when the aircraft has climbed to 480 ft.

(INTC) Conditional waypoint; the leg terminates when the aircraft intercepts the course of the next leg.

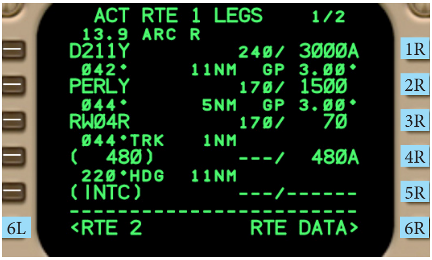
JFK/03 Conditional waypoint; the leg terminates when the distance between the aircraft and the JFK DME is 3 nm.

JFK180 Conditional waypoint; the leg terminates when the aircraft crosses the 180° radial of the JFK VOR.

VECTORS The crew has to terminate the leg manually by entering the next or any other waypoint into the first line. (when instructed by ATC).

(continued next page)

LEGS Page: *(continued)*



Valid entries in 1R to 5R
Step climb advisory on a cruise leg:
XXXS
FLXXXS
Altitude constraint (-1005 to 45100 ft) on a departure or arrival leg:
XXXA
XXXB
XXXXXAXXXXXB
FLXXX
Speed constraint (IAS 100 to 399 kt) if altitude constraint is already entered:
XXX/
Speed constraint/altitude constraint:
XXX/XXX
XXX/XXXXA
XXX/FLXXX
Speed constraints must be combined with altitude constraints.—Mach constraints are invalid.

6L <RTE 1 or <RTE 2 or <ERASE
Opens the LEGS page of the other route. When the page shows a modified route, the key reads <ERASE which allows the crew to cancel the modification.

6R ACTIVATE> or RTE DATA>
If the route is inactive, arms it for activation, otherwise opens the RTE DATA page.

Leg lines
The *right-hand* side shows the IAS or Mach number, and the barometric altitude at leg termination; predictions are shown in small font, constraints in large font, for example:

.865/FL310S The S-suffix indicates that the crew will start a cruise step climb when this leg becomes active. This is not an autopilot function; it is a manual entry to inform the FMC about planned, ATC instructed step climbs, so that the FMC can provide more accurate performance predictions.

240/ 3000A The FMC predicts an IAS of 240 kt, and there is an *A*-type altitude constraint: the aircraft must be *at or above* 3000 ft when terminating the leg.

170/ 1500 The FMC predicts an IAS of 170 kt, and the aircraft must be *at* 1500 ft when terminating the leg.

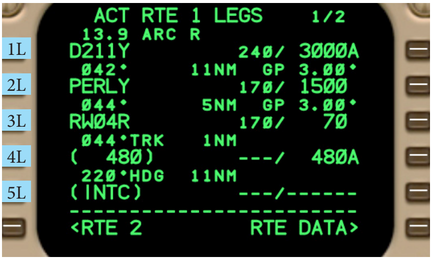
250/12000B The IAS has to be 250 kt, and the aircraft must be *at or below* 12000 ft (*B*-type) when terminating the leg.

.711/FL170AFL190B The FMC predicts a Mach number of 0.711, and there is an *AB*-type altitude constraint: the aircraft must be *at or above* FL170 and *at or below* FL190 when terminating the leg.

---/------ No computed predictions.

(continued next page)

LEGS Page: *(continued)*



Valid entries in 1L to 5L

Any waypoint, station, or airport identifier in the database or route; or coordinates, for example:

For N27° 59.7' E086° 55.8'
enter N2759.7E08655.8
For N27° 00.0' E086° 00.0'
enter N27E086

One destination runway, for example:

For runway 07 enter RW07 or 07.

Place-bearing/distance, for example:

For 5 nm from JFK on 090° bearing
enter JFK090 / 5

Place-bearing/place-bearing, for example:

For the intersection of JFK bearing 270°
with LGA bearing 180°
enter JFK270 / LGA180

Along-track waypoint, for example:

For a point 2 nm after PERLY,
on the leg to RW04R,
enter PERLY/2 over PERLY.
For a point 2 nm before PERLY,
on the leg from D211Y,
enter PERLY/-2 over PERLY.

(continued next box)

Valid entries in 1L to 5L *(continued)*

Single latitude or longitude crossing point in the route, for example:

To find the next crossing of the S02° latitude in the route, starting the search on the 7th leg,
enter S02 in the 7th leg.
(When the crossing is found in the 9th leg, for instance, the FMC will insert a new waypoint named S02 before the 9th waypoint.)

Latitude or longitude crossing *intervals*, for example:

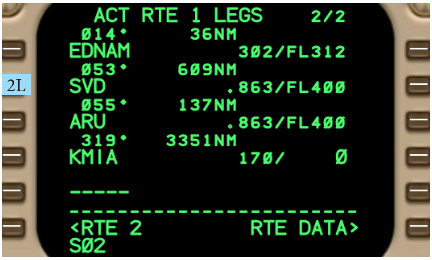
To create multiple crossing points at 5° longitude intervals, starting at the first crossing of the E024° longitude,
enter E024-5 in the first leg.
(When the crossing is found in the 20th leg, for instance, the FMC will insert a new waypoint named E024 before the 20th waypoint, and insert additional points named E029, E034, and so on, at the respective geographic crossing points along the remainder of the route.)

(For examples on latitude and longitude crossing points, refer to the next two pages in this chapter.)

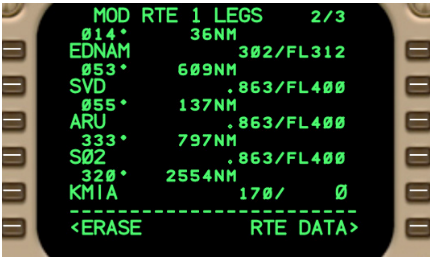
(continued next page)

LEGS Page: *(continued)*

Single **lat/lon crossing point** – example:



Find the first crossing of the S02° latitude along the route, starting the search at SVD. (If the route follows a zigzag course, or is straight and long enough, the route may cross the S02° latitude more than once; hence, the definition of the starting point may be important. Otherwise, start the search in the first leg.)



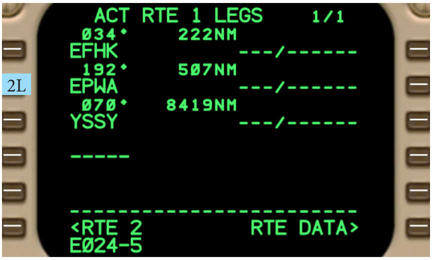
When S02 is entered in 2L, the FMC will check all legs after SVD and recognize the S02° latitude is first crossed on the leg between ARU and KMIA; and will insert a new waypoint named S02 before KMIA.

This feature also works with N latitudes, and with W and E longitudes. If a crossing is not possible, the entry is invalid.

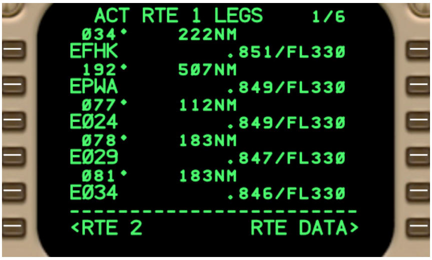
(continued next page)

LEGS Page: *(continued)*

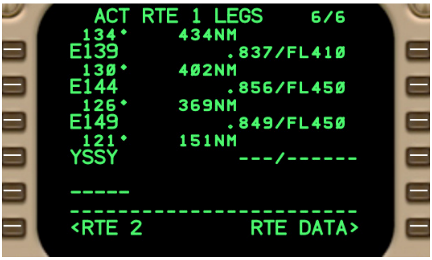
Lat/lon crossing *intervals* – example:



Find the first E024° longitude crossing on the active route, starting the search at EPWA. (If the route follows a zigzag course, or is straight and long enough, the route may cross the E024° longitude more than once; hence, the definition of the starting point may be important. Otherwise, start the search in the first leg.)



6 pages in total



When E024-5 is entered over EPWA, the FMC will find out that the first crossing lies between EPWA and YSSY, and will insert multiple waypoints at longitude intervals of 5° along the route until the end of the route (the FMC will create five more LEGS pages).

This feature also works with W longitudes, and with N and S latitudes. If a crossing is not possible, the entry is invalid.

Refer to the next page for a map view of this example.

(continued next page)

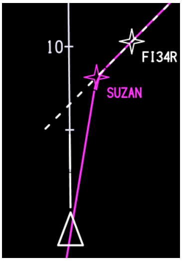
LEGS Page: *(continued)*

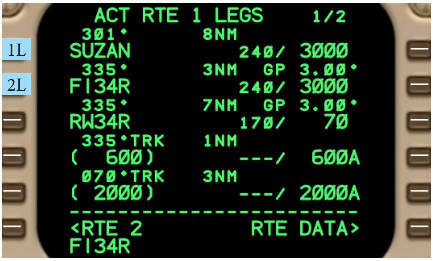
Map view of the example on the previous page
On the leg from EPWA direct to YSSY along a great circle course (shortest distance), the FMC has generated multiple route waypoints, placed on every fifth longitude, starting at E024°.

(continued next page)

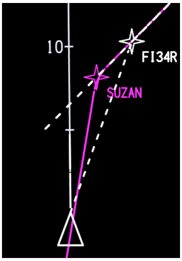
LEGS Page: *(continued)*

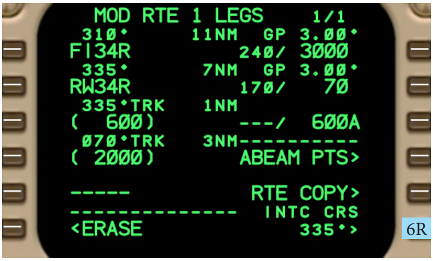
Intercept-course-to – **example 1:**



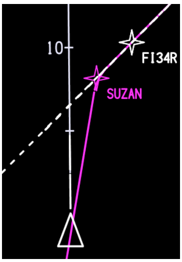


Say, ATC instructs to maintain the present heading to intercept the final approach course to FI34R.—Downselect 2L to the scratchpad, then upselect it to 1L.

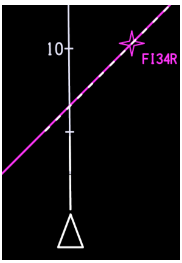


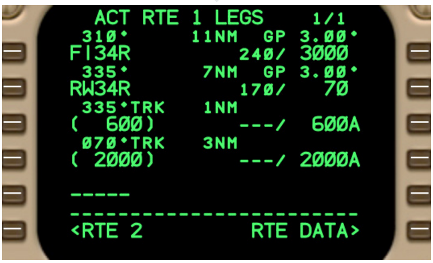


In the modified route, FI34R is now the first waypoint. In 6R, the FMC suggests an intercept course of 335°, displayed in small font with a caret.—Select this caret.



335° is now displayed in large font, and the ND shows an extended approach course line (white dashes) leading to FI34R. (Similar to the white dashes of the runway centerline.)



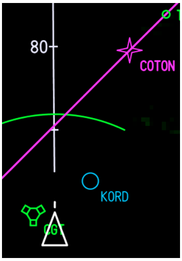


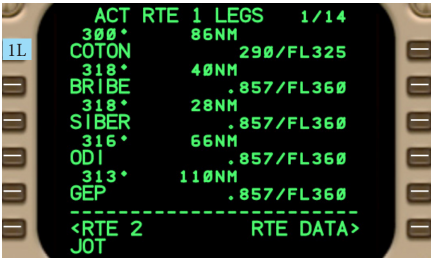
Press the EXEC key.—The extended approach course is now a magenta, continuous line. The line title in 1L indicates 310°; this is the *current direct* track to FI34R (not the approach course).

(continued next page)

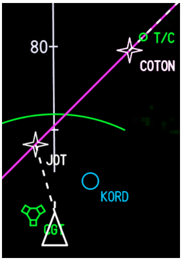
LEGS Page: *(continued)*

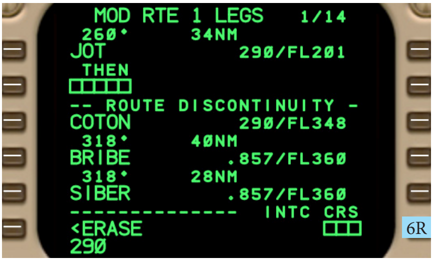
Intercept-course-to – example 2:



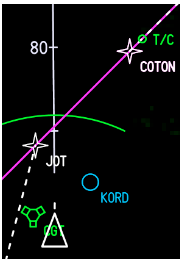


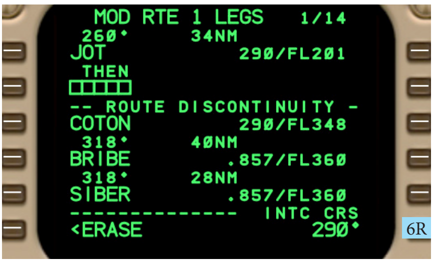
Say, ATC instructs to join the 290° inbound course to JOT.—Type JOT into the scratchpad, then upselect it to 1L.





When a fix is entered that is not in the current route, the FMC inserts a discontinuity after that entry; when such a fix is entered in the *first* leg, 6R displays boxes.—Type 290 into the scratchpad.



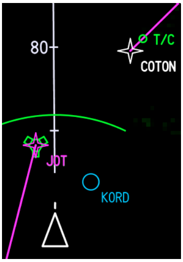


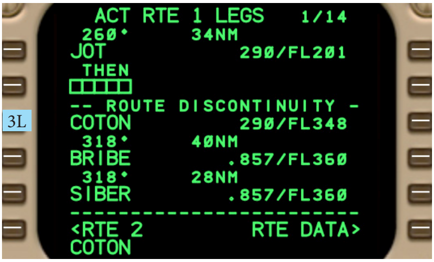
Upselect the 290 value to 6R.—To activate the modification, press the EXEC key. Refer to the next page on how to close the discontinuity.

(continued next page)

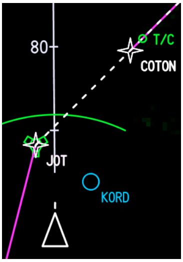
LEGS Page: *(continued)*

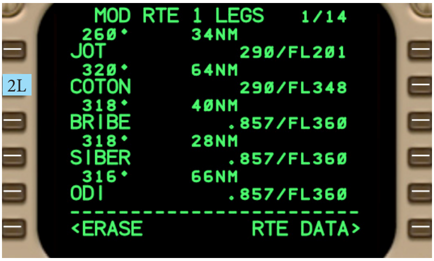
Closing a route discontinuity – example:



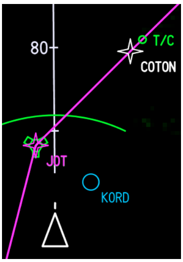


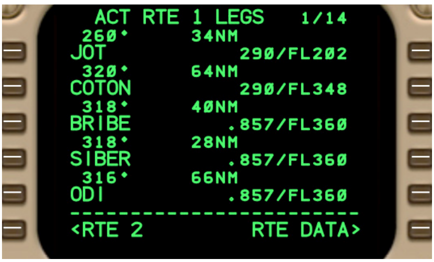
Downselect the fix after the discontinuity to the scratchpad; in this case, COTON from 3L.





Then upselect COTON into the boxes of the discontinuity in 2L.
—When entering a fix that *is* already in the route, the FMC will not insert a discontinuity.



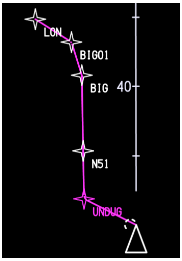


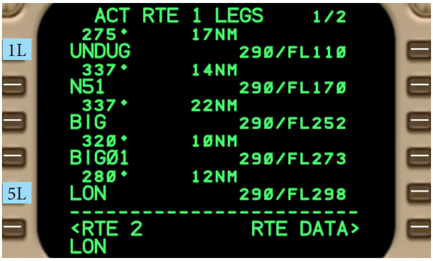
Press the EXEC key.
—The modification is now active.

(continued next page)

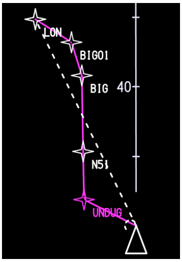
LEGS Page: *(continued)*

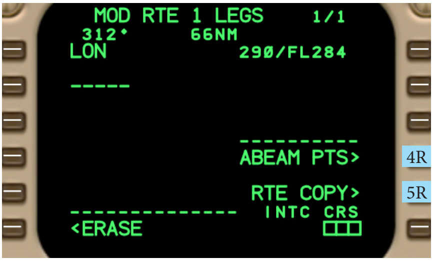
Direct-to via abeam points – example:



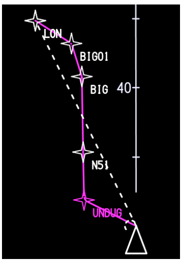


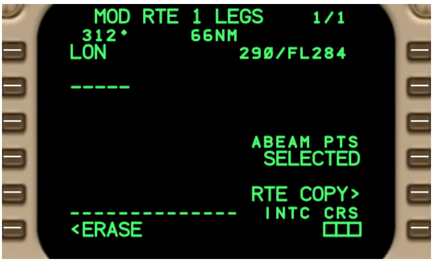
N51 is a latitude crossing point, BIG01 a place-bearing/distance point, the rest are database fixes.—Downselect 5L to the scratchpad, then upselect it to 1L to create a direct-to LON leg.



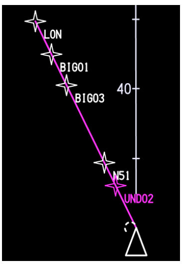


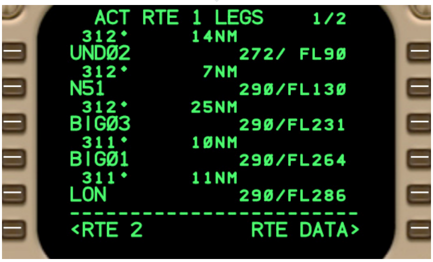
(If desired, copy the unmodified RTE 1 to RTE 2 by selecting 5R.) Select 4R.—This will shift the skipped points abeam the new leg onto that leg when the EXEC key is pushed.





When 4R is selected, SELECTED is indicated. To activate this modification, press the EXEC key.

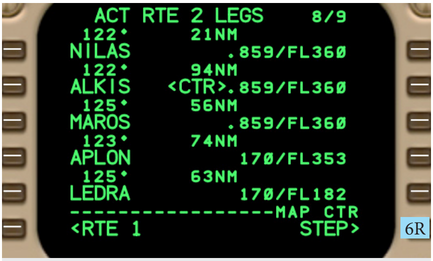




The shifted points are now visible. N51 still crosses the N51° latitude. The place-bearing/distance data of BIG01 are adjusted. The other points are renamed to UND02 and BIG03.

(continued next page)

LEGS Page: *(continued)*



ND plan display control
When the ND mode is set to PLN (plan) on the onside EFIS control, the LEGS page on the onside CDU shows a <CTR> flag in the middle of the page and a STEP> key in 6R. Pushing this key advances the <CTR> flag from waypoint to waypoint. The waypoint marked with <CTR> is in the center of the ND plan.

Flight level display format
An altitude in a leg is displayed in feet format if it belongs to a departure and the altitude is at or below the transition *altitude*, or belongs to an arrival and the altitude is below the transition *level*. Otherwise, the altitude is displayed in flight level FLXXX format. The crew entered format has no influence on the display format.

Speed and altitude predictions for arrival
For arrival legs, the FMC can only compute speed and altitude predictions when there is an altitude constraint at or near the destination.

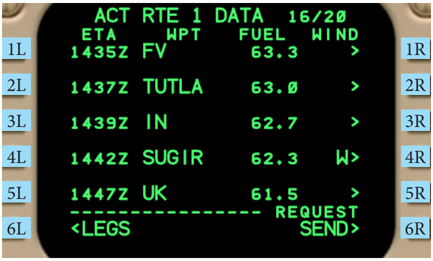
Fly-by and fly-over waypoints
A pilot entered waypoint is always a fly-*by* waypoint. A fly-*over* waypoint may appear in a route when a departure or arrival procedure is loaded from the database, and the procedure contains such a waypoint.

Identifiers of created waypoints
Created place-bearing/distance (PBD) waypoints, place-bearing/place-bearing (PBPB) waypoints, and along-track waypoints, are automatically renamed by the FMC. If the identifier of the referred waypoint consists of more than 3 letters, only the first three letters will be used. The FMC will attach a 2-digit serial number after the identifier. The number increases whenever a new waypoint is created. The numbering system is not linked with the sequence of the legs, but with the sequence of the waypoint creation. The number 00 is reserved for PBD and PBPB entries on the PROGRESS 1/3 page (in 4L). Latitude-longitude waypoints will get 7-letter identifiers: N27° 59.7' E086° 55.8', for example, will get the identifier N27E086.

Downselected waypoint data
Downselecting a waypoint to the scratchpad will show a format depending on the waypoint type: PBD, PBPB, and along-track waypoints will show PBD data in the format ABC090.5/0023.4. Latitude-longitude waypoints will show their coordinates in the format N2759.7E08655.8. All other waypoints will show their identifier only. However, the identifier may be upselected to 1L on the REF NAV DATA page; that page will display the coordinates.

Maximum amount of legs
The maximum amount of legs the FMC can store per route is 120.

RTE DATA Page:



Access:
- 6R on ACT LEGS
- 6R on waypoint WIND

General:
Indicates predicted ETA and fuel data at waypoints. Provides an ACARS based data request function, and access to waypoint WIND pages.

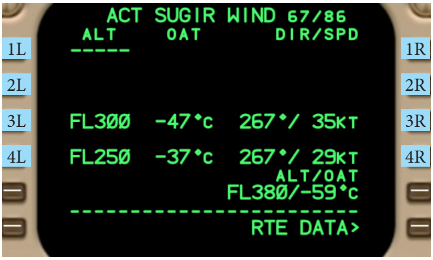
1L 2L 3L 4L 5L ETA WPT FUEL
Each line indicates the ETA at the respective waypoint, along with the waypoint identifier, and the fuel remaining at that waypoint. All data are estimations calculated by the FMC. The indications are blank when the FMC is recalculating the data, or when there are no computed data.—Before takeoff, when a takeoff time is entered on the PROGRESS 3/3 page in line 3R, the ETAs are based on that entered takeoff time, otherwise on the current FMC time displayed on the POS INIT 1/3 page in line 4L.—For route discontinuities, the FMC assumes direct connections.

1R 2R 3R 4R 5R W> or >
Opens the WIND page for the respective waypoint. The W before the caret indicates that the associated WIND page contains data (data entries in large font).

6L <LEGS or <ERASE
Opens the associated LEGS page of the displayed waypoints. When the route is modified, or when new wind data are loaded, the key reads <ERASE which allows the crew to cancel the modification or the loaded wind data.

6R SEND> or LOAD>
SEND> initiates a downlink request (down to a ground station) for enroute wind and temperature forecast data. When selected, SENDING will be displayed. When receipt is acknowledged, SENTSEND> will be displayed. LOAD> is shown when data uplink is ready, which may take 10 seconds or more *(in the simulator, the time can be accelerated on* ***Instructor*** *>* ***Situation*** *>* ***Time****)*. In case of a fault, line title reads DATA LINK and key reads FAIL (ACARS fault), NO COMM (radio or FMC fault), or VOICE (radio not on ACARS frequency).

Waypoint WIND Page:



Access:
1R, 2R, 3R, 4R, 5R on RTE DATA.

General:
Displays forecast winds and temperatures at a route waypoint, used by the FMC to improve performance prediction calculations. Data can be modified by manual entries or by ACARS uplinks.

1L 2L 3L 4L ALT OAT

Displays up to four altitudes. Deletion is allowed in all four lines. Entry is allowed in 1L when dashes are shown. Altitudes are automatically sorted in 1L through 4L, and appear on all pages.—In the middle of a line, the OAT at the respective altitude is shown if an OAT reference is entered in 5R. The FMC propagates this OAT reference vertically to the other altitudes at this waypoint, based on standard temperature lapse rates.—OAT and wind data at each altitude are propagated horizontally to adjacent waypoints if an adjacent waypoint contains no entered data. Propagated data are displayed in small font, entered data in large font.—For the performance predictions, the FMC uses a mixing algorithm, taking into account the forecast wind and the current IRS computed wind. For the present position the FMC uses 0% forecast wind and 100% IRS wind. Along the route, the ratio gradually reverses to 100% forecast with 0% IRS wind. The ratio is 50% to 50% at 200 nm ahead of the aircraft. During climb and descent, the algorithm is based on vertical distances: in climb, the 50% to 50% point is at 5000 ft above the aircraft; in descent 5000 ft below it. The FMC applies this algorithm also for forecast OATs and the current ADC computed SAT.

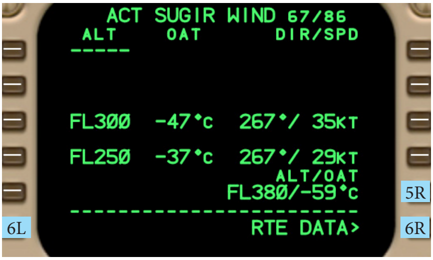
1R 2R 3R 4R DIR/SPD

Displays the forecast wind at the respective altitude. Data entries are displayed in large font, propagated data in small font. If no wind entry and no propagated data exist, dashes are displayed; in that case, the FMC will interpolate the data internally as follows: winds above the highest altitude entry are all equal; for winds below the lowest altitude entry, wind directions are all equal, with wind speeds gradually decreasing to 0 kt at destination elevation, or at MSL if a destination is not entered.

Valid entries
Wind speed (0 to 250 kt) if direction is already entered:
X
XX
XXX
Wind direction (0° to 360°) if speed is already entered:
XXX/
Wind direction/wind speed:
XXX/X
XXX/XX
XXX/XXX

(continued next page)

Waypoint WIND Page: *(continued)*



5R ALT/OAT
Displays altitude/OAT reference for vertical propagation in 1L through 4L.

Valid entries
Altitude (-1005 to 45100 ft)/OAT: XXX/-XX XXXX/X XXXXX/-X FLXXX/-XX Valid OAT minimum is -80°C. Valid OAT maximum varies with altitude, for example: Maximum is +50°C at up to 2610 ft. Maximum is 0°C at up to FL263.

6L ERASE> or blank
Displays <ERASE when data is modified, to allow the crew to cancel the modification.

6R RTE DATA>
Opens the RTE DATA page.

HOLD Page:

Access:
HOLD key if the route contains a hold

General:
Provides functions to modify a hold. When the aircraft is in a hold, executed modifications appear only after the next fix crossing. Initial settings are based on standard rules or on values in database.

1L FIX
Displays holding fix.

2L QUAD/RADIAL
Allows data entry in ATC clearance language (quadrant/VOR radial). Also updates the data in 3L accordingly. If the entered quadrant data disagrees with the entered radial data, the FMC automatically displays the correct quadrant.

Valid entries
Radial (000° to 359°):
XXX
Quadrant (N, NE, E, SE, S, SW, W, NW) /radial:
X/XXX
XX/XXX

3L INBD CRS/DIR
Displays inbound course and turn direction. Data entry also updates 2L unless 2L displays dashes.

Valid entries
Inbound course (000° to 359°):
XXX
Turn direction (L or R):
X
/X
Inbound course/turn direction:
XXX/X

4L LEG TIME
Shows the leg time if 5L displays dashes. Data entry causes 5L to display dashes.

Valid entries
Time (0.1 to 9.9 minutes):
X
X.X
.X

5L LEG DIST
Shows the leg distance if 4L displays dashes. Data entry causes 4L to display dashes.

Valid entries
Distance (0.1 to 99.9 nm):
X
XX
X.X
XX.X
.X

6L <NEXT HOLD or <ERASE
Displays <ERASE when data are modified. Otherwise, displays the <NEXT HOLD key which provides functions to select a fix for another holding pattern (refer to the page after the next in this chapter).

(continued next page)

HOLD Page: *(continued)*

1R SPD/TGT ALT

Indicates the speed and target altitude as shown on the right-hand side of the LEGS page. For more information, refer to **LEGS page** in this chapter.

Valid entries
Altitude constraint (-1005 to 45100 ft):
XXXA
XXXXB
XXXXXAXXXXXB
FLXXX
Speed constraint (IAS 100 to 399 kt) if altitude constraint is already entered:
XXX/
Speed constraint/altitude constraint:
XXX/XXX
XXX/XXXXA
XXX/FLXXX
Speed constraints must be combined with altitude constraints.—Mach constraints are invalid.

2R FIX ETA

Indicates the next ETA at the fix. When an EFC time is entered in 3R, indicates the final ETA based on the EFC time.

3R EFC TIME

Allows entry of an expect-further-clearance (EFC) time. The FMC will apply this for all ETA and fuel predictions in the remainder of the route. Blank for fix terminated holds.

Valid entries
Hours and minutes (0000z to 2359z):
XXXX

4R HOLD AVAIL

Displays available holding time until hold must be exited to land at destination with fuel reserves entered on PERF INIT page in line 4L. Blank for fix terminated holds.

5R BEST SPEED

Indicates the most fuel saving holding speed for the current flap setting, gross weight, and altitude.

6R EXIT HOLD> or EXIT ARMED

When selected, indicates EXIT ARMED, and when the EXEC key is pushed, the aircraft will turn to the inbound course and exit the hold. Manual exit is not required if the hold was loaded with a procedure and is of a hold type that will auto-exit when reaching a specific altitude or when crossing the holding fix for the first time.

(continued next page)

HOLD Page: *(continued)*

To create a new holding pattern, push the HOLD key, then—if a hold is already in the route—push the <NEXT HOLD key on the HOLD page. This will open the LEGS page with boxes in 6L and the PPOS> key in 6R.

Creating a hold at an *existing* route waypoint – example:

Downselect ARTIP to the scratchpad and upselect it to 6L. This will open the HOLD page with ARTIP as the holding fix. If a hold at ARTIP is in the database, those data will be initially displayed; otherwise, standard rules will be displayed, with the inbound course equal to the route leg course to ARTIP. Set all data and push the EXEC key.

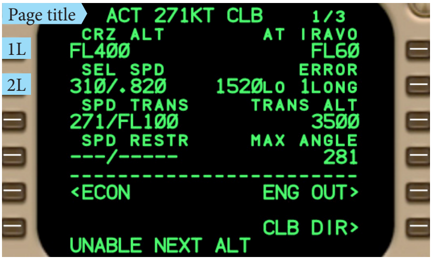
Creating a hold at a *new* route waypoint – example:

Type MYN into the scratchpad and upselect it to 6L. As MYN is not in the route yet, the upselection to 6L will cause the scratchpad to display HOLD AT MYN. Upselect this to the desired leg before which the route should lead to the hold at MYN. This will also open the HOLD page with MYN as the holding fix. If a hold at MYN is in the database, those data will be initially displayed; otherwise, standard rules will be displayed. Set all data as required, then push the EXEC key.

Creating a hold at the *present position*:

Push the PPOS> key in 6R. This will create a latitude-longitude waypoint at the present aircraft position, with a hold at that waypoint. This will also open the HOLD page with that new waypoint as the holding fix, and with standard rules initially displayed. Set all data as required, then push the EXEC key.

VNAV CLB Page:



Access:

VNAV key, then—if not in climb—PREV PAGE or NEXT PAGE.

Autoselected on inital flap retraction if TAKEOFF REF page is shown.

General:

Provides performance and vertical navigation functions for the climb phase.

Page title Current speed mode

When the FMC is in climb mode, the page title indicates MOD when data are modified, or ACT when active data are shown. Also displays the current speed mode, for example:

271KT	VNAV commands 271 kt as required by initial V2 and VREF additions; or as set by speed/altitude restrictions, limits, or constraints; or as entered by the crew.
.812M	VNAV commands 0.812 Mach as entered by the crew.
E/O	VNAV commands engine-out speed loaded from performance database.
E/O 234KT	VNAV commands engine-out speed entered by the crew.
ECON	VNAV commands cost index based economic speed.
LIM SPD	Desired speed is below or above current aerodynamic limit; for example, above flap limit speed. VNAV commands limit speed.
MCP SPD	VNAV commands MCP speed selected by the crew.

1L CRZ ALT

Shows cruise altitude.

Valid entries
Altitude (-1005 to 45100 ft):
XXX
XXXX
XXXXX
FLXXX

2L Unrestricted target command speed

Line title indicates ECON SPD for cost index based economic speeds, E/O SPD for engine-out speeds, or SEL SPD for manually entered speeds.

Valid entries
IAS (100 to 400 kt):
XXX
Mach number (0.100 to 0.990):
.X
.XX
.XXX
IAS/Mach number:
XXX/.X
XXX/.XX
XXX/.XXX
Mach number/IAS:
.X/XXX
.XX/XXX
.XXX/XXX

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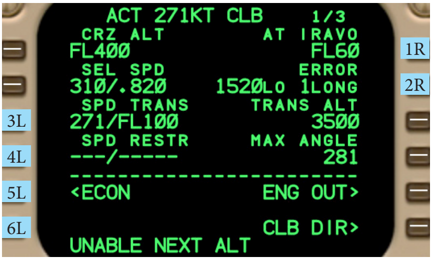
VNAV CLB Page: *(continued)*



3L SPD TRANS

Shows the speed limit and associated speed limit transition altitude of the origin airport loaded from the database. If limits are not specified in the database, the FMC sets 250/10000. If the speed limit (250 or database value) is lower than VREF+100, the FMC raises the limit to that value.
—The actual command speed will not exceed waypoint speed constraints.
—3L is blank when the aircraft is above the speed transition altitude, or when 4L contains a higher altitude and a lower speed, or when 3L is manually deleted. Manual *entries* are not possible.

4L SPD RESTR

Allows the crew to enter a speed restriction and an associated altitude below which the speed restriction is to be applied. Displays dashes when the aircraft is above the entered altitude, or when the entry is deleted.

Valid entries
Speed (100 to 399 kt)/altitude
(higher than origin elevation, lower than cruise altitude):
XXX / XXX
XXX / XXXX
XXX / XXXXX
XXX / FLXXX

5L <ECON or <E/O SPD

Shows <ECON when 2L indicates SEL SPD in all-engines mode. Shows <E/O SPD when 2L indicates SEL SPD in engine-out mode. Selects the respective speed mode.

6L <ERASE or blank

Shows <ERASE when data are modified. Selection erases the modification; pushing the EXEC key activates the modification.

1R Waypoint constraint

Shows the next waypoint speed/altitude constraint in the climb section of the route. Deletion of 1R is allowed. Entries are only allowed on the LEGS page.

2R ERROR

Shows predicted undershoot with reference to the altitude constraint displayed in 1R. In the above example, 1520LO means the aircraft will cross IRAVO at an altitude 1520 ft below FL60; 1LONG means the aircraft will reach FL60 at 1 nm after IRAVO. Blanks when no error is predicted.

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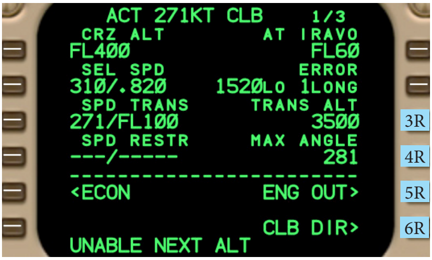
VNAV CLB Page: *(continued)*



3R TRANS ALT

Shows the transition altitude for the departure. When no manual entry exists, shows transition altitude for the SID loaded from the database. When no manual and no database entry exists, shows the default altitude of 18000 ft. The FMC uses the transition altitude as a reference for the altitude indications in the climb section of the route; they are accordingly shown in feet format or flight level format. It is also used for the QNH/STD altimeter switch-over advisory on the PFDs during departure.

Valid entries
Altitude (-1005 to 32005 ft):
XXX
XXXX
XXXXX
FLXXX

4R MAX ANGLE or MAX ALT

Shows the maximum angle climb speed when in all-engines mode; shows the maximum achievable altitude when in engine-out mode.

5R ENG OUT> or ALL ENG>

Selection of ENG OUT> causes the FMC to lower the cruise altitude to the current maximum engine-out altitude if it is exceeded, and to change the command speed to the engine-out speed. The data are based on one-engine-out conditions, unless the FMC detects that two or more engines are inoperative, in which case the data are based on those conditions. Performance predictions will be adjusted accordingly.
—Selection of ALL ENG> changes the command speed to ECON speed.

6R CLB DIR>

Displayed when the climb section of the route contains a waypoint altitude constraint. Selection deletes all waypoint constraints that are below the MCP altitude, and that belong to the climb section of the route.

VNAV CRZ Page:

Access:
VNAV key, then—if not in cruise—
PREV PAGE or NEXT PAGE.

General:
Provides performance functions for the cruise phase, including cruise climb and cruise descent.

Page title **Current speed mode**
When the FMC is in cruise mode, the page title indicates MOD when data are modified, or ACT when active data are shown. Also displays the current command speed mode, for example:

297KT CRZ	Crew selected IAS for cruise.
.820M CRZ	Crew selected Mach for cruise.
E/O 274KT CRZ	Crew selected engine-out speed for cruise.
E/O 274KT D/D	Crew selected engine-out speed for drift down to E/O altitude.
E/O CRZ	Engine-out speed for cruise.
E/O D/D	Engine-out speed for drift down.
E/O LRC CRZ	Engine-out long range cruise speed.
ECON CRZ	Economic speed for cruise.
ECON CRZ CLB	Economic speed for cruise climb.
ECON CRZ DES	Economic speed for cruise descent.

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LIM SPD CRZ	Limit speed for cruise (desired speed is below or above current aerodynamic limit).
LRC CRZ	LRC speed for cruise.
LRC D/D	LRC speed for drift down.
MCP SPD CRZ	MCP speed for cruise.
RTA CRZ	RTA speed for cruise.

1L **CRZ ALT**
Shows cruise altitude.

Valid entries
Altitude (-1005 to 45100 ft):
XXX
XXXX
XXXXX
FLXXX

(continued next page)

VNAV CRZ Page: *(continued)*

2L Command speed

Line title indicates ECON for economic, E/O for engine-out, LRC for long range cruise, or SEL for manually entered speed.

> **Valid entries**
> IAS (100 to 400 kt):
> XXX
> Mach number (0.100 to 0.990):
> .X
> .XX
> .XXX

3L Target thrust

Indicates thrust required to maintain command speed at cruise altitude.

A Thrust is indicated by EPR *(PW and RR engines)* or by N1 *(GE engines)*.

4L STEP SIZE

Displays the step size used for cruise step climb computations. No step climb will occur when zero is entered. Default entry is ICAO which applies ICAO flight level separation rules for step sizes.

> **Valid entries**
> Increments of 1000 (0 to 9000), or ICAO:
> 0
> X000
> ICAO
> I

5L <ECON or <E/O SPD

Shows <ECON when in all-engines mode and ECON is not shown in 2L. Shows <E/O SPD when in engine-out mode and E/O is not shown in 2L. Selects the respective speed mode.

6L <ERASE or <RTA PROGRESS

Shows <ERASE when data are modified; otherwise, opens the RTA PROGRESS 3/3 page.

1R STEP TO

Indicates the next cruise altitude for the next step climb. Blanks when the aircraft is within 200 nm of the T/D. Indication in small font refers to FMC computed step-to recommendations, based on optimum altitudes and the entered step size: the FMC keeps as much as possible the step climb profile near the gradual optimum altitude profile. Indication in large font refers either to a manual step-to entry in 1R, or to a waypoint altitude marked by an S-suffix on the LEGS page. Deletion of 1R is not allowed, but large-font entries can be reset to small font by entering a cruise altitude in 1L. Modifications in 1R are immediately active; the EXEC key is not required.

> **Valid entries**
> Altitude (higher than cruise altitude, but not higher than FL450):
> XXX
> XXXX
> XXXXX
> FLXXX

(continued next page)

VNAV CRZ Page: *(continued)*

2R AT
When AT is displayed in the line title, the data in 2R indicates the ETA and distance to go to the point where the crew should start the next step climb. NOW is indicated when this point is passed, or NONE when the point lies past the 200 nm limit of the T/D. Line title changes to AVAIL AT when a crew entered waypoint altitude with an S-suffix is in the legs that is higher than the maximum achievable altitude at that waypoint; in this case, 2R indicates when and where this S-altitude can be achieved. Line title reads TO XXX during E/O drift down, whereas XXX is the target cruise altitude. Line title reads TO T/D when the aircraft is within 200 nm of the T/D. Data in 2R always refer to the respective current line title.

3R Destination ETA/FUEL
Indicates predicted ETA and fuel remaining at the destination, based on the entered or recommended step climb schedule. Line title includes ICAO identifier of destination airport. W/MOD is indicated before the ETA display when a data modification is present; in this case, ETA and fuel refer to the modification.

4R OPT MAX
Indicates the current optimum altitude and the current maximum altitude.

5R ENG OUT> or ALL ENG>
Selection of ENG OUT> causes the FMC to change the command speed to the engine-out speed, and to lower the cruise altitude to the current maximum engine-out altitude if it is exceeded, in which case a drift down will be initiated (when the MCP altitude is reset to that lower altitude). The data are based on one-engine-out conditions, unless the FMC detects that two or more engines are inoperative, in which case the data are based on those conditions. Performance predictions will be adjusted accordingly.
—Selection of ALL ENG> changes the command speed to ECON speed.

6R LRC>
Shown when the command speed is not in long range cruise (LRC) mode. Selects LRC speed mode. LRC speed approximately corresponds to an ECON speed at cost index 230 under zero wind conditions.

VNAV DES Page:

Access:
VNAV key, then—if not in descent—
PREV PAGE or NEXT PAGE.

General:
Provides performance functions and vertical navigation references for the descent phase of the flight.

Page title **Current speed mode**
When the FMC is in descent mode, the page title indicates MOD when data are modified, or ACT when active data are shown. Also displays the current speed mode, for example:

240KT	VNAV commands 240 kt as set by speed/altitude restrictions, limits, or constraints; or as entered by the crew.
.812M	VNAV commands 0.812 Mach as entered by the crew.
ECON	VNAV commands cost index based economic speed.
LIM SPD	Desired speed is below or above current aerodynamic limit; for example, above flap limit speed. VNAV commands limit speed.
MCP SPD	VNAV commands MCP speed selected by the crew.
END OF	End of descent is reached and there is no missed approach.

1L **E/D AT**
Shows end of descent altitude and waypoint.

2L **Current command speed**
Line title indicates ECON SPD for cost index based economic speeds, or SEL SPD for manually entered speeds.

Valid entries
IAS (100 to 400 kt):
XXX
Mach number (0.100 to 0.990):
.X
.XX
.XXX
IAS/Mach number:
XXX/.X
XXX/.XX
XXX/.XXX
Mach number/IAS:
.X/XXX
.XX/XXX
.XXX/XXX

(continued next page)

VNAV DES Page: *(continued)*

3L SPD TRANS

Shows the speed limit transition altitude and associated speed limit (of the destination airport loaded from the database) minus 10 kt. If limits are not specified in the database, the FMC sets 240/10000.
—The actual command speed will not exceed waypoint speed constraints.
—3L is blank when the aircraft is below the speed transition altitude, or when 4L contains a higher altitude and a lower speed, or when 3L is manually deleted. Manual *entries* are not possible.

4L SPD RESTR

Allows the crew to enter a speed restriction and an associated altitude below which the speed restriction is to be applied. Displays dashes when the aircraft is below the entered altitude, or when the entry is deleted.

Valid entries
Speed (100 to 399 kt)/altitude (higher than E/D altitude, lower than cruise altitude):
XXX/XXX
XXX/XXXX
XXX/XXXXX
XXX/FLXXX

6L <ERASE or <OFFPATH

Shows <ERASE when data are modified; otherwise, opens the OFFPATH DES page.

1R Waypoint constraint

Shows the next waypoint speed/altitude constraint in the descent section of the route. Deletion of 1R is allowed. Entries are only allowed on the LEGS page.

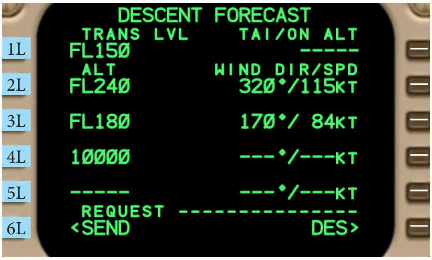
5R FORECAST>

Opens the DESCENT FORECAST page.

6R DES NOW> or DES DIR>

DES NOW> is displayed when the descent is not active; selection initiates the descent now, before the T/D is reached. Otherwise DES DIR> is shown when the descent section of the route contains a waypoint altitude constraint before the E/D; selection deletes all waypoint constraints before the E/D that are above the MCP altitude, and that belong to the descent section of the route.

DESCENT FORECAST Page:



Access:

- 5R on VNAV DES
- 2L on FMC COMM 1/2

General:

The FMC uses the forecast data in the calculation of the T/D for an idle descent to the first waypoint constraint. The EXEC key is not required on this page.

1L TRANS LVL

Shows the transition level for the arrival. When no manual entry exists, shows the transition level for the arrival loaded from the database. Shows FL180 when no manual and no database entry exists. The FMC uses the transition level as a reference for the altitude indications in the arrival section of the route; they are accordingly shown in feet format or flight level format. It is also used for descent path calculations (true heights of altitude constraints above the transition level vary with barometric pressure), and for the QNH/STD altimeter switch-over advisory on the PFDs during arrival.

Valid entries
Altitude (-1005 to 32005 ft):
XXX
XXXX
XXXXX
FLXXX

2L 3L 4L 5L ALT

Allows the crew to enter an altitude with reference to the forecast wind entry on the right-hand side of the respective line. Altitude entries are automatically sorted, with the highest altitude shown in 2L.

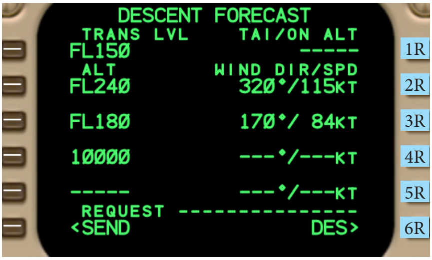
Valid entries
Altitude (-1005 to 45100 ft):
XXX
XXXX
XXXXX
FLXXX

6L <SEND> or <LOAD

<SEND initiates a downlink request (down to a ground station) for descent forecast data. When selected, SENDING will be displayed. When receipt is acknowledged, <SENDSENT will be displayed. <LOAD is shown when data uplink is ready, which may take 10 seconds or more *(in the simulator, the time can be accelerated on **Instructor > Situation > Time**)*. In case of a fault, line title reads DATA LINK and key reads FAIL (ACARS fault), NO COMM (radio or FMC fault), or VOICE (radio not on ACARS frequency).

(continued next page)

DESCENT FORECAST Page: *(continued)*



1R TAI/ON ALT

Allows the crew to enter an altitude at which thermal anti-ice (TAI) is expected to be activated. (When activated, the idle thrust will be higher, resulting in a shallower descent path angle; for this reason, the entered altitude is an essential variable in the FMC's T/D calculation.)

> **Valid entries**
> Altitude (-1005 to 45100 ft):
> XXX
> XXXX
> XXXXX
> FLXXX

2R 3R 4R 5R WIND DIR/SPD

Allows an entry of a forecast wind with reference to the altitude in the same line.

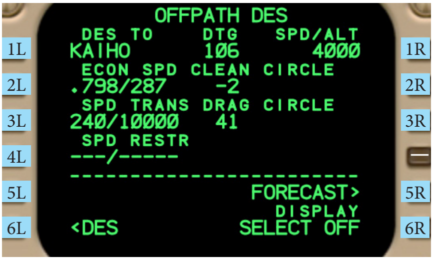
> **Valid entries**
> Wind speed (0 to 250 kt) if direction is already entered:
> X
> XX
> XXX
> Wind direction (0° to 360°) if speed is already entered:
> XXX/
> Wind direction/wind speed:
> XXX/X
> XXX/XX
> XXX/XXX

6R DES> or PURGE>

When <LOAD is shown in 6L, PURGE> is shown in 6R, allowing the crew to cancel the data uplink. Otherwise, DES> is shown which opens the VNAV DES page.

> **SYSTEM ANALYSIS**
> In the simulator, a graph of the FMC computed, predicted idle descent path is shown on **Instructor > Analysis > Navigation**. (In the simulator's main network, the graph is shown on the server only.)

OFFPATH DES Page:



Access:
6L on VNAV DES

General:
Shows T/D arcs (circles) for an off-route, crew selected target altitude and target waypoint in the vicinity of the aircraft. Computations take into account the data from the DESCENT FORECAST page.

1L DES TO DTG
Shows the descent-to waypoint the circles refer to. The default waypoint is the E/D of the active route. Manual entries and deletions are promptly activated; the EXEC key is not required as this is a display function only.—In the middle of the line, under DTG, indicates the direct distance to go to that waypoint.

> **Valid entries**
> Any waypoint, station, or airport identifier in the database or active route.

2L 3L 4L 5L
Same functions as on the VNAV DES page. Refer to **VNAV DES Page** in this chapter.

6L <ERASE or <DES
Shows <ERASE when any data in 2L through 5L are modified; otherwise, opens the VNAV DES page.

1R SPD/ALT
Indicates the speed/altitude constraint at the descent-to waypoint entered in 1L. May be manually overwritten; manual entry will not overwrite the waypoint's actual constraint shown on the LEGS page. Manual entries and deletions are promptly activated; the EXEC key is not required as this is a display function only. Initially shows boxes when an off-route waypoint is entered in 1L. When the entered altitude is higher than the current aircraft altitude, 1L and 1R return to the default display.

> **Valid entries**
> Altitude (-1005 to 45000 ft):
> XXX
> XXXX
> XXXXX
> FLXXX

2R CLEAN CIRCLE
Indicates the distance to go to the T/D for a clean idle descent to the target in 1L and 1R.

3R DRAG CIRCLE
Same function as 2R, but with speedbrakes.

5R FORECAST>
Opens the DESCENT FORECAST page.

6R SELECT ON> or SELECT OFF>
Shows or hides the circles on the onside ND.

FMC COMM 1/2 Page:

Access:
FMC COMM key

General:
Provides quick access to all FMC pages that include an ACARS data link function.

1L <RTE 2 or <RTE 1
Opens the first RTE page of the active route, or of route 1 if neither route is active. Line title indicates UPLINK when a route uplink is ready.

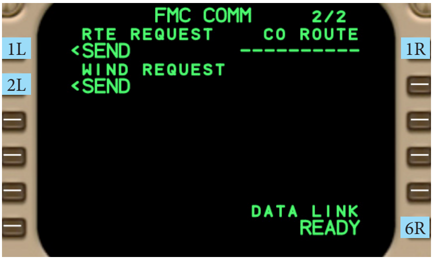
2L <DES FORECAST
Opens the DESCENT FORECAST page. Line title indicates UPLINK when a descent wind data uplink is ready.

3L <RTE DATA
Opens the RTE DATA page of the active or modified route. Line title indicates UPLINK when an enroute wind data uplink is ready.

1R POS REPORT
Opens the POS REPORT page.

6R DATA LINK
Indicates READY when the data link is operative. In case of a fault, indicates FAIL (ACARS fault), NO COMM (radio or FMC fault), or VOICE (radio not on ACARS frequency).—For operational requirements re ACARS communication, refer to chapter **Communications**.

FMC COMM 2/2 Page:



Access:
FMC COMM key, then NEXT PAGE

General:
Provides quick access to all ACARS based data request functions.

1L **<SEND RTE REQUEST**
Initiates a downlink route request (down to the ground station) if a valid route identifier is entered in 1R. When initiated, SENDING will be displayed. When the receipt of the request is acknowledged, <SENDSENT will be displayed. The line title in 1L on the FMC COMM 1/2 page will indicate UPLINK when the route uplink is ready, which may take 30 seconds or more *(in the simulator, the time can be accelerated on **Instructor > Situation > Time**)*.

2L **<SEND WIND REQUEST**
Initiates a downlink request (down to the ground station) for enroute wind and descent wind data. When initiated, SENDING will be displayed. When the receipt of the request is acknowledged, <SENDSENT will be displayed. The line title in *3L* on the FMC COMM 1/2 page will indicate UPLINK when the data uplink is ready, which may take 10 seconds or more *(in the simulator, the time can be accelerated on **Instructor > Situation > Time**)*. When the enroute wind data are loaded, the line title in *2L* on the FMC COMM 1/2 page will indicate UPLINK. This means, first the enroute wind data are to be loaded, then the descent wind data.

1R **CO ROUTE**
The identifier of a company route may be entered that is not in the on-board database and that the crew wants to request from dispatch using the <SEND key in 1L.

Valid entries
Any entry (1 to 10 characters).

6R **DATA LINK**
Indicates READY when the data link is operative. In case of a fault, indicates FAIL (ACARS fault), NO COMM (radio or FMC fault), or VOICE (radio not on ACARS frequency).—For operational requirements re ACARS communication, refer to chapter **Communications**.

POS REPORT Page:

Access:

- 6L on PROGRESS 1/3
- 1R on FMC COMM 1/2

General:

Shows position data and other information that may be sent to company dispatch or to air traffic control.

1L LAST

Shows last waypoint.

2L ALT

Shows aircraft altitude at last waypoint.

3L TO

Shows active waypoint. May be overwritten.

Valid entries
Any entry (1 to 7 characters).

4L NEXT

Shows next waypoint. May be overwritten.

Valid entries
Any entry (1 to 7 characters).

5L TEMP WIND

Shows current ADC computed SAT and current IRS computed wind.

6L <SEND COMPANY

Initiates a downlink report (down to dispatch) of the data shown. When initiated, SENDING will be displayed. When the receipt of the report is acknowledged, <SENDSENT will be displayed.

1R ATA

Actual time of arrival at the last waypoint.

2R SPD

Shows current command speed. May be overwritten (for report display only).

Valid entries
IAS (100 to 999 kt):
XXX
Mach number (0.10 to 0.99):
.XX

3R ETA

ETA at active waypoint. May be overwritten.

Valid entries
Hours:minutes (0000 to 2359z):
XXXX

4R DEST ETA

ETA at destination. May be overwritten.

Valid entries
Hours:minutes (0000 to 2359z):
XXXX

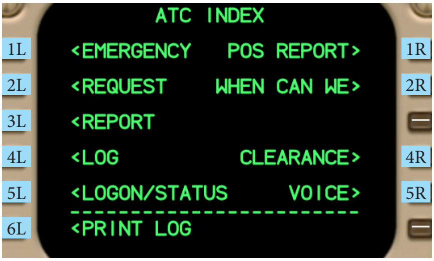
5R FUEL

Shows current fuel remaining.

6L ATC SEND>

Initiates a downlink report (down to ATC) of the data shown. When initiated, SENDING will be displayed. When the receipt of the report is acknowledged, <SENDSENT will be displayed.

INDEX Page:



In the simulator, a CPDLC controller console is modelled on **Instructor** > **Situation** > **Human** > **CPDLC** for ATC communication with the pilot operating the simulated aircraft. The console allows manual and random control.

Access:

- ATC key when connected and no new and no open message in log
- 6L on any indexed page other than POS REPORT page

General:

Shows an index of all pages that refer to CPDLC (FANS-1 implementation). CPDLC stands for **controller-pilot data link communication**. CPDLC is an international, standardized method; while FANS-1 is a special on-board implementation allowing the pilot to apply CPDLC. An initial concept of FANS—short for **future air navigation system**—was published by ICAO in 1988. Actual implementations are manufacturer specific: Boeing uses FANS-1 and -2, Airbus uses FANS-A and -B.

1L **<EMERGENCY**
Opens the EMERGENCY REPORT page.

2L **<REQUEST**
Opens the REQUEST page.

3L **<REPORT**
Opens the REPORT page.

4L **<LOG**
Opens the LOG page.

5L **<LOGON/STATUS**
Opens the LOGON/STATUS page.

6L **<PRINT LOG**
Prints the LOG pages. Indicates PRINTER FAIL when printer is inoperative.

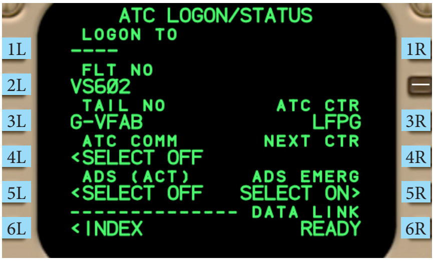
1R **POS REPORT>**
Opens the POS REPORT page.

2R **WHEN CAN WE>**
Opens the WHEN CAN WE EXPECT page.

4R **CLEARANCE>**
Opens the VERIFY REQUEST page for a clearance request.

5R **VOICE>**
Opens the VERIFY REQUEST page for a voice contact request.

LOGON/STATUS Page:



Access:
- ATC key when not connected
- 5L on INDEX page

General:
Provides connection functions and indications. For operational requirements re ACARS communication, refer to chapter **Communications**.

1L LOGON TO
During connection process, shows entered ICAO code of ATC center to which logon is required. When connected, displays dashes to allow logon to a different ATC center. Displays boxes when not connected.

> **Valid entries**
> 4-letter ICAO code of ATC center.
> *(In the simulator, any 4-letter entry can establish ATC communication.)*

2L FLT NO
Shows flight number. Display is linked with entry in 2R on first RTE page.

> **Valid entries**
> Any entry (1 to 10 characters).

3L TAIL NO
Shows ICAO registration of this aircraft.

4L <SELECT OFF ATC COMM
Disconnects current communication link.

5L <SELECT OFF or <SELECT ARM
Disconnects or arms automatic dependent surveillance (ADS). ADS status is indicated in line title by OFF, ACT, or ARM flag.

6L <INDEX
Opens the INDEX page.

1R LOGON SEND> or blank
Shows SEND> when data are entered in 1L and 2L, and when 6R indicates READY. When SEND> is selected, shows SENDING (sending logon message to controller). When receipt of logon message is acknowledged, shows SENT, otherwise RESEND>. When ATC center has responded, shows either REJECTED or ACCEPTED for 2 seconds, then blanks.

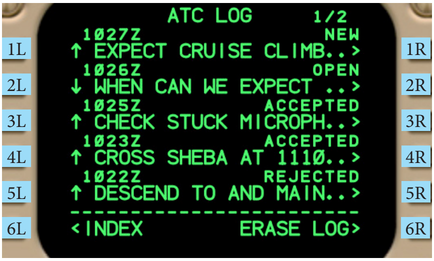
3R ATC CTR
Shows ICAO code of active ATC center.

4R NEXT CTR
Shows ICAO code of next ATC center if system is able to determine it *(in the simulator always unable).*

5R <SELECT ON or <SELECT OFF
Manually activates or deactivates the ADS emergency mode. ADS emergency mode is automatically activated when an emergency report has been sent.

6R DATA LINK
Indicates READY when data link is ready. In case of a fault, indicates FAIL (ACARS fault), NO COMM (radio or FMC fault), or VOICE (radio not on ACARS frequency).

LOG Page:



Access:

- ATC key when connected; and more than one new message in log, or no new message in log and more than one open message in log.
- 4L on INDEX page.

General:

Shows headers of logged messages.

1L 2L 3L 4L 5L **Message header**

Arrow up indicates an uplink, arrow down a downlink message. Shows the initial words of a message. Line title to the left indicates the time of the message transmission, and to the right the message status:

ACCEPTED	Pilot has reviewed the uplink message and has sent ACCEPT.
NEW	Pilot has not reviewed the uplink message.
OLD	Pilot has reviewed the uplink message and a response is not required.
OPEN	Pilot (or ATC) has reviewed the uplink (or downlink) message requiring a response, but has not replied or has sent STANDBY.
REJECTED	Pilot has reviewed the uplink message and has responded with a rejection.

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RESPONSE RCVD	ATC has received the downlink message and has responded with a rejection or an instruction.
SENT	ATC has received the downlink message and a response is not required.

(A message is considered “reviewed by the pilot” when the pilot has selected the page that shows the content of the message.)

Single messages may be deleted using the DEL key.

6L **<INDEX**

Opens the INDEX page.

1R 2R 3R 4R 5R **>**

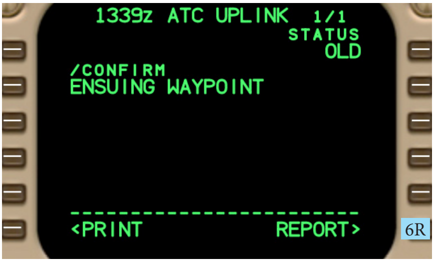
Selects respective message page for review.

6R **ERASE LOG>** or **CONFIRM>**

When selected, displays CONFIRM>. When confirmed, erases all logged messages except for new and open messages.

In the simulator, when saving a situation file, only the last logged message will be saved.

UPLINK Page (Message to Pilot):



Access:
- ATC key when one new message, or no new and one open message in log.
- Any right-hand key on LOG page that refers to an uplink message.

General:
Shows message from controller. 6R opens REPORT page if uplink requires a report.

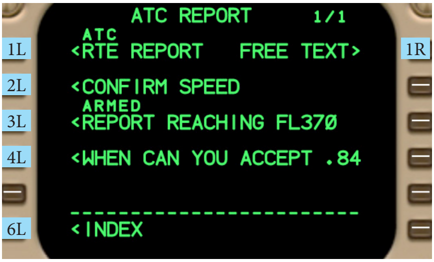
Example of a logged uplink, requesting to confirm an information. The pilot has confirmed the information (status: OLD).

Example of a logged uplink, requesting a report. The pilot has accepted the request, but has not sent the requested report yet.

Example of a logged uplink, requesting a When Can You Accept response. The pilot has responded (status: OLD).

Example of an instruction, displayed across two pages. The last page provides the response functions <STANDBY, <REJECT, and ACCEPT>. These functions will open the respective VERIFY page that includes the SEND> key.

REPORT Page (Message to Controller):



Access:

- 3L on INDEX.
- 6R on UPLINK page if message type is Confirm, Report, or When Can You.

General:

Provides access to VERIFY REPORT pages. *(In the simulator, the number of prepared VERIFY REPORT pages, that are accessed through this REPORT page, is limited to five. There can be just one <CONFIRM key, one <REPORT key, and one <WHEN CAN YOU ACCEPT key. They refer to the latest uplinks. Previous references will be overwritten. The keys in 1L and 1R are always available.)*

1L **<RTE REPORT**

Opens a VERIFY REPORT page prepared for an assigned-route report.

2L **<CONFIRM ...**

Opens a VERIFY REPORT page prepared for a confirmation. *(In the simulator, this type of page is always accessed through 2L.)*

3L **<REPORT ...**

Opens a VERIFY REPORT page prepared for a conditional report. Line title indicates ARMED when the system is armed for an automatic report. *(In the simulator, this type of page is always accessed through 3L.)*

4L **<WHEN CAN YOU ACCEPT ...**

Opens a VERIFY REPORT page prepared for a When Can You Accept response. *(In the simulator, this type of page is always accessed through 4L.)*

6L **<INDEX**

Opens the INDEX page.

1R **FREE TEXT>**

Opens a VERIFY REPORT page prepared for a free text report.

VERIFY REPORT Page:

Example of a page used solely for a free-text report.

Access:
Any report key on REPORT page

General:
Provides prepared report settings as selected on REPORT page. Some settings may be modified. 6L returns to REPORT page. 5R sends report and opens page of sent report with UTC in title.

Example of a route report page. 1L indicates the active route (RTE1 or RTE2).

Example of a conditional report page. 1R shows ARM>, or ARMED when selected. When armed, the FMC will trigger the report automatically.

Example of a confirmation page. 1L may be overwritten.

Example of a We Cannot Accept report. Initially, 2L displays boxes to allow a time entry, and 3L shows <CANNOT ACCEPT in small font. It is shown in large font when selected. It returns to small font when deleted or when a time is entered in 2L.

Sent REPORT Page (Message to Controller):

Example of a logged report that was sent when the aircraft was passing FL420.

Access:

Opens when a report has been sent, or when selected on LOG page for review.

General:

Shows sent report for review. 6L prints the report. 6R opens the LOG page. Page title indicates time of transmission.

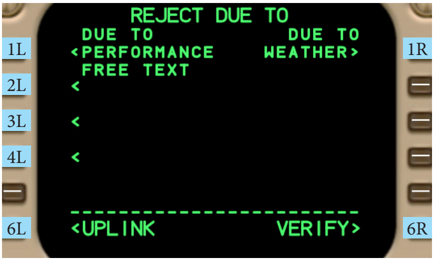
Example of a logged report that confirmed the speed at 1316z.

Example of a logged report that confirmed the next after the active waypoint at 1341z.

Example of a logged We Cannot Accept report with a free text attachment.

Example of a logged We Can Accept report transmitted at 1343z.

REJECT DUE TO Page (Message to Controller):



Access:
<REJECT key on any new or open instructional UPLINK page (on last page of uplink if uplink text is shown on multiple pages)

General:
Allows the pilot to state the reason for the rejection of an instruction.

1L <PERFORMANCE
Adds DUE TO PERFORMANCE to the message text. May be removed by line deletion or by selecting 1R.

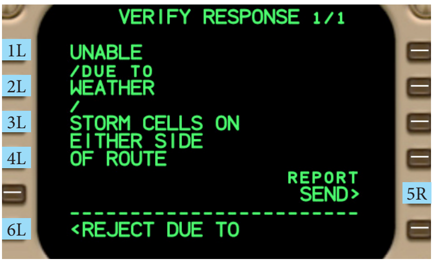
2L 3L 4L FREE TEXT
Free text may be attached to the message.

6L <UPLINK
Reopens the UPLINK page the rejection refers to.

1R WEATHER>
Adds DUE TO WEATHER to the message text. May be removed by line deletion or by selecting 1L.

6R VERIFY>
Opens the VERIFY RESPONSE page.

VERIFY RESPONSE Page:



Access:

- 6R on REJECT DUE TO
- <STANDBY on UPLINK
- ACCEPT> on UPLINK

General:
Shows the text of the response for verification, and provides the SEND> key.

1L 2L 3L 4L Text to be sent
First line may read UNABLE, STANDBY, WILCO, AFFIRM, or ROGER, depending on the type of response.

6L <UPLINK or <REJECT DUE TO
Reopens the page the verification refers to.

5R SEND>
Sends response and reopens UPLINK page the response refers to, indicating the updated status in 1R (REJECTED, ACCEPTED, or OPEN).

EMERGENCY REPORT Page:

Access:

- Push and hold ATC key for 1 second (if connection exists)
- 1L on INDEX page

General:

Provides text elements for an emergency report.

1L <MAYDAY

When selected, shows MAYDAY in large font, adds MAYDAY MAYDAY MAYDAY to the text, removes PAN selection, and opens VERIFY EMERGENCY page.

2L DIVERT TO

Shows destination airport in small font with a caret if entered in route, otherwise displays dashes. Adds entered data to text.

Valid entries
4-letter ICAO code of airport.

3L OFFSET

Shows offset if entered, otherwise dashes. Adds entered data to text.

Valid entries
Left or right distance (0 to 99 nm):
LX
LXX
RX
RXX

4L DESCENT TO

Shows MCP altitude in small font with a caret, or entered descent-to altitude in large font. Adds entered data to text.

Valid entries
Altitude (0000 to 99999 ft):
XXXX
XXXXX
Flight level (000 to 999):
XXX
FLXXX

5L <ERASE or <CANCEL

<ERASE deletes all entries on this page. When deleted, shows <CANCEL; if that is selected, text will include the words CANCEL EMERGENCY, which means, the last reported emergency status is now to be canceled.

6L <INDEX

Opens the INDEX page.

(continued next page)

EMERGENCY REPORT Page: *(continued)*

1R PAN>
When selected, shows PAN in large font, adds PAN PAN PAN to the text, removes MAYDAY selection, and opens VERIFY EMERGENCY page.

2R SOB
Shows the entered number of souls on board (SOB); that is, the sum of passengers and crew. Shows dashes if no data is entered.

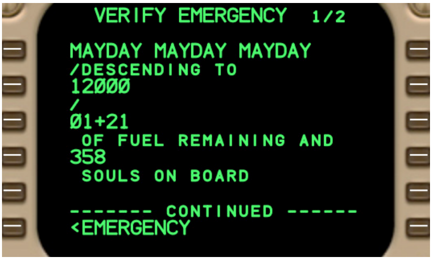
> **Valid entries**
> Number (0 to 999):
> X
> XX
> XXX

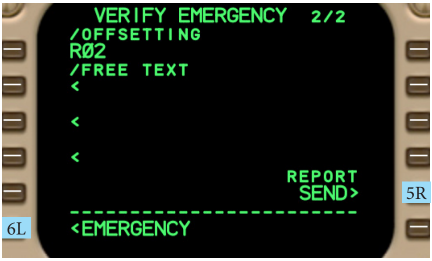
3R FUEL REMAINING
Blank when no SOB data is entered in 2R, otherwise indicates FMC calculated fuel remaining and flight time available. Time may be manually overwritten. Fuel value is indicated in kg x 1000 or lb x 1000 as per system option setting.

> **Valid entries**
> Hours+minutes (0+00 to 99+59):
> X+XX
> XX+XX

6R VERIFY>
Opens the VERIFY EMERGENCY page.

VERIFY EMERGENCY Page:



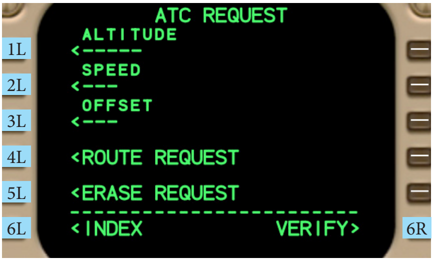


Example of a report containing multiple text elements, displayed across two VERIFY EMERGENCY pages. Free text may be attached.

Access:
6R on EMERGENCY REPORT page

General:
Shows the text of the report on one or more pages for verification. 6L returns to the EMERGENCY REPORT page. 5R on the last page sends the report and opens a page of the sent report with the transmission time in the title, and also activates the ADS emergency mode on the LOGON/STATUS page in 5R.

REQUEST Page (Message to Controller) for Navigational Request:



Access:
2L on INDEX page

General:
Provides forms to enter text for a request. Keys 1L through 3L will open the associated page regardless whether data is in the scratchpad or not.

1L <----- **ALTITUDE**
Opens the ALT REQUEST 1/4 page. Data entry is optional. Deletion will erase all entries on ALT REQUEST 1/4 page.

Valid entries
Altitude (0000 to 99999 ft):
XXXX
XXXXX
Flight level (000 to 999):
XXX
FLXXX
Block altitude:
XXX/XXX
XXXXX/XXXXX

2L <--- **SPEED**
Opens the SPEED REQUEST 2/4 page. Data entry is optional. Deletion will erase all entries on SPEED REQUEST 2/4 page.

Valid entries
IAS (100 to 999 kt):
XXX
Mach number (.01 to .99):
.X
.XX

3L <--- **OFFSET**
Opens the OFFSET REQUEST 3/4 page. Data entry is optional. Deletion will erase all entries on the OFFSET REQUEST 3/4 page.

Valid entries
Left or right distance (0 to 99 nm):
LX
LXX
RX
RXX

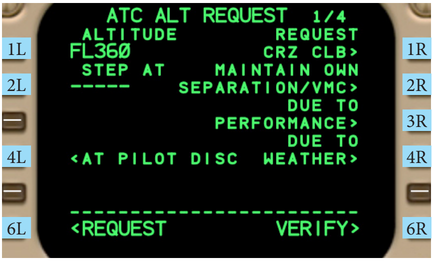
4L **<ROUTE REQUEST**
Opens the ROUTE REQUEST 4/4 page.

5L **<ERASE REQUEST**
Erases the entries in all four request pages. Blank when no entries exist.

6L **<INDEX**
Opens the INDEX page.

6R **VERIFY>**
Opens the VERIFY REQUEST page which shows the text elements selected on all four REQUEST pages (speed, offset, and so on).

ALT REQUEST Page (Message to Controller):



Access:
1L on REQUEST page

General:
Allows selection of message elements referring to an altitude request. This is page 1 of 4. The total number of message elements on all four pages is limited to five (plus free-text element).

1L **ALTITUDE**
Shows requested altitude, or block altitude.

Valid entries
Altitude (0000 to 99999 ft):
XXXX
XXXXX
Flight level (000 to 999):
XXX
FLXXX
Block altitude:
XXX/XXX
XXXXX/XXXXX

2L **STEP AT**
Optionally shows the time or waypoint for a step up or step down to requested altitude. Blank when entry in 1L is a block altitude.

Valid entries
Identifier (1 to 7 characters) or time:
XXXXZ

4L **<AT PILOT DISC**
Adds AT PILOT DISCRETION to the text.

6L **<REQUEST**
Opens the REQUEST page.

1R **CRZ CLB>**
Inserts CRUISE CLIMB TO in the message text. Blanks if requested altitude is a block altitude, or if it is below the current FMC cruise altitude.

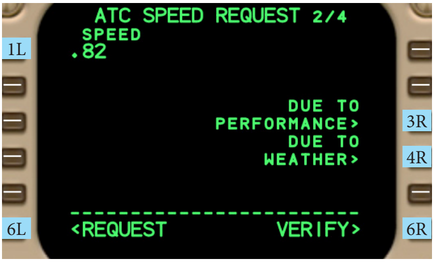
2R **SEPARATION/VMC>**
Adds MAINTAIN OWN SEPARATION AND VMC to the text.

3R **PERFORMANCE>**
Adds DUE TO PERFORMANCE to the message text. Removed when 4R is selected.

4R **WEATHER>**
Adds DUE TO WEATHER to the message text. Removed when 3R is selected.

6R **VERIFY>**
Opens the VERIFY REQUEST page which shows the text elements selected on all four REQUEST pages.

SPEED REQUEST Page (Message to Controller):



Access:
2L on REQUEST page

General:
Allows selection of message elements referring to a speed request. This is page 2 of 4. The total number of message elements on all four pages is limited to five (plus free-text element).

1L **SPEED**
Shows requested speed.

Valid entries
IAS (100 to 999 kt):
XXX
Mach number (.01 to .99):
.X
.XX

3R **PERFORMANCE>**
Adds DUE TO PERFORMANCE to the message text. Removed when 4R is selected.

4R **WEATHER>**
Adds DUE TO WEATHER to the message text. Removed when 3R is selected.

6L **<REQUEST**
Opens the REQUEST page.

6R **VERIFY>**
Opens the VERIFY REQUEST page which shows the text elements selected on all four REQUEST pages.

OFFSET REQUEST Page (Message to Controller):

Access:
3L on REQUEST page

General:
Allows selection of message elements referring to an offset request. This is page 3 of 4. The total number of message elements on all four pages is limited to five (plus free-text element).

1L OFFSET
Shows requested route offset.

Valid entries
Left or right distance (0 to 99 nm):
LX
LXX
RX
RXX

2L OFFSET AT
Optionally shows the time or waypoint for the start of the offset.

Valid entries
Identifier (1 to 7 characters) or time:
XXXXZ

4R WEATHER>
Adds DUE TO WEATHER to the message text.

6L <REQUEST
Opens the REQUEST page.

6R VERIFY>
Opens the VERIFY REQUEST page which shows the text elements selected on all four REQUEST pages.

ROUTE REQUEST Page (Message to Controller):

Access:
4L on REQUEST page

General:
Allows selection of message elements referring to route requests. This is page 4 of 4. The total number of message elements on all four pages is limited to five (plus free-text element).

1L DIRECT TO
Shows requested direct-to waypoint, or dashes.

Valid entries
Waypoint identifier (1 to 7 characters).

1R HEADING
Shows requested heading, or dashes.

Valid entries
Heading (000° to 359°):
XXX

2R GROUND TRACK
Shows requested ground track, or dashes.

Valid entries
Track (000° to 359°):
XXX

3L <RTE1
Requests route 1 to be activated.

3R RTE2>
Requests route 2 to be activated.

5L DEP/ARR
Shows requested departure or arrival procedure, including transition if required, or dashes. Shows current procedure in route in small font with a caret; shown in large font when selected.

Valid entries
Procedure identifiers (1 to 12 characters).

6L <REQUEST
Opens the REQUEST page.

6R VERIFY>
Opens the VERIFY REQUEST page which shows the text elements selected on all four REQUEST pages.

VERIFY REQUEST Page for Navigational Request:

Example of a request containing multiple text elements, displayed across two VERIFY REQUEST pages. Free text may be attached.

Access:
6R on any REQUEST page

General:
Shows the text of the request on one or more pages for verification. 6L returns to the REQUEST page. 5R on the last page sends the request and opens a page of the sent request with UTC in the title.

Sent REQUEST Page (Message to Controller) for Navigational Request:

Example of a request sent by the pilot at 1607z. When 1R indicates OPEN, the controller has not responded yet. When it indicates STANDBY, the controller has responded with a “standby” message. When it indicates RESPONSE RCVD, the controller may have sent “unable”, in which case UNABLE will be indicated on the last page, along with the time of the response; or the controller has sent an instruction, in which case 1L on the first page will show <UPLINK as in the example below:

Selection of <UPLINK in 1L will show the controller’s response (an instruction) to this request.

Access:
Opens when a request has been sent, or when selected on LOG page.

General:
Shows sent request for review. Page title indicates UTC of transmission. May consist of multiple pages. The examples to the left just show page 1 of 2.

UPLINK Page (Message to Pilot):

Selection of <REQUEST in 1L on this UPLINK page will show the pilot’s request this uplinked response refers to.

WHEN CAN WE EXPECT Page (Message to Controller):

Access:
2R on INDEX page

General:
Provides text elements for a When Can We Expect request.

1L 2L 3L Requested altitude
Allows entry of an altitude for cruise climb (1L), climb (2L), or descent (3L). Any entry blanks all other altitude related lines; line deletion redisplays all altitude related lines.

Valid entries
Altitude (0000 to 99999 ft):
XXXX
XXXXX
Flight level (000 to 999):
XXX
FLXXX

4L SPEED
Shows requested speed, or dashes.

Valid entries
IAS (100 to 999 kt):
XXX
Mach number (.01 to .99):
.X
.XX

5L <ERASE WHEN CAN WE
Erases all selections on this page. Blank when no selection exists.

6L <INDEX
Opens the INDEX page.

2R HIGHER ALT>
Adds HIGHER ALT to the text. Selection blanks all other altitude related lines; line deletion redisplays all altitude related lines.

3R LOWER ALT>
Adds LOWER ALT to the text. Selection blanks all other altitude related lines; line deletion redisplays all altitude related lines.

4R BACK ON RTE>
Adds BACK ON ROUTE to the text. May be removed by line deletion.

6L VERIFY>
Opens the VERIFY REQUEST page.

VERIFY REQUEST Page for Inquiry:

Example of a request containing multiple text elements, all displayed on one VERIFY REQUEST page. Free text may be attached.

Access:
6R on WHEN CAN WE EXPECT page

General:
Shows the text of the request. 6L returns to the WHEN CAN WE EXPECT page. 5R sends the request and opens a page of the sent request with UTC in the title.

Sent REQUEST Page (Message to Controller) for Inquiry:

In this example, the controller has sent "unable"; therefore, UNABLE is indicated on the last page, along with the time of the response.

Access:
Opens when a request has been sent, or when selected on LOG.

General:
Shows sent request for review. Page title indicates UTC of transmission. May consist of multiple pages. The examples to the left show page 1/2 and page 2/2.

VERIFY REQUEST Page for Clearance Request:

Example of a request containing the text element "REQUEST CLEARANCE". Free text may be attached.

Access:
4R on INDEX page

General:
Shows the text for a clearance request. 6L returns to the INDEX page. 5R sends the request and opens a page of the sent request with UTC in the title.

VERIFY REQUEST Page for Voice Contact Request:

Example of a request containing the text element "REQUEST VOICE CONTACT". Free text may be attached.

Access:
5R on INDEX page

General:
Shows the text for a voice contact request. 6L returns to the INDEX page. 5R sends the request and opens a page of the sent request with UTC in the title.

FMC Scratchpad Messages:

High priority messages (accompanied by EICAS advisory)	
ATC COMM ESTABLISHED	CPDLC is available.
ATC MSG NOT ACKNOWLEDGED	Downlink sent and network acknowledgement not received *(in the simulator, controller faults will never occur).*
ATC REPORT LIST FULL	More than nine reports are to be sent *(in the simulator, this message will never appear; there can be five reports, and a new report of the same type will overwrite the previous).*
CHECK ALT TGT	VNAV is engaged and holds current altitude because aircraft is between FMC target altitude and MCP altitude.
CYCLE IRS OFF-NAV	A fault requires IRS selectors to be set to OFF and back to NAV.
DES FORECST UPLINK READY	Descent forecast wind data are uplinked and ready to be loaded into the FMC.
DESCENT PATH DELETED	VNAV is engaged and all waypoint constraints for the descent path are deleted.
DISCONTINUITY	LNAV is engaged and maintains last heading because the active leg is not defined.
DRAG REQUIRED	VNAV is engaged while aircraft is above planned descent path; and A/T is off and thrust is above idle, or is at idle and speed brakes are required.
END OF OFFSET	LNAV is engaged and end of offset route will be reached in less than 2 minutes.
END OF ROUTE	Active LEGS page is empty; LNAV is engaged and maintains last heading.
ENTER IRS POSITION	IRS in align mode and IRS position is not entered.
FLT NUMBER UPLINK	Flight number uplink received and inserted in flight plan *(in the simulator, flight numbers need to be entered manually).*
FMC () OUTPUT DATA LOSS	FMC (L or R) data output fault *(in the simulator, this fault will never occur).*

(continued next page)

FMC Scratchpad Messages: *(continued)*

High priority messages (accompanied by EICAS advisory)	
FUEL DISAGREE - PROG 2	Disagreement between calculated and totalizer fuel by 4080 kg (9000 lb) or more.
ILS TUNE INHIBITED - MCP	ILS tuning has been attempted while any of the following conditions is true: • Any autopilot is engaged, and LOC or G/S mode is engaged. • Any flight director is engaged, and LOC or G/S mode is engaged, and radio altitude is below 500 ft. • Aircraft is on the ground, and heading is within 45° of localizer front course, and groundspeed is greater than 40 kt.
INSUFFICIENT FUEL	Predicted fuel remaining at destination is less than fuel reserves on PERF INIT page.
INVALID ATC UPLINK	Message from controller contains a fault *(in the simulator, this fault will never occur).*
INVALID FLT NO UPLINK	Message from dispatch contains a fault *(in the simulator, this fault will never occur).*
INVALID FORECAST UPLINK	Descent wind forecast data uplink contains a fault and the FMC rejects the data.
INVALID ROUTE UPLINK	Flight plan route uplink contains a fault and the FMC rejects the data.
INVALID WIND DATA UPLINK	Enroute wind forecast data uplink contains a fault and the FMC rejects the data.
IRS NAV ONLY	FMC computes the aircraft position without GPS and without radio updating.
IRS POS/ORIGIN DISAGREE	Aircraft on ground and excessive disagreement between IRS computed aircraft position and origin airport location.
LIMIT ALT FL...	Pilot arms VNAV while aircraft is above maximum altitude of current performance mode. Message indicates maximum altitude.
MESSAGE LIMIT EXCEEDED	Pilot attempted to add a 6th text element to a downlink report or request.

(continued next page)

FMC Scratchpad Messages: *(continued)*

High priority messages (accompanied by EICAS advisory)	
NAV DATA OUT OF DATE	Aircraft on ground and FMC date exceeds cycle date of active navigation database.
NAV INVALID - TUNE ...	Signals missing from VOR or DME required for approach procedure. Message indicates the identifier of the required station.
NO ACTIVE ROUTE	Pilot arms LNAV while there is no active route.
PARTIAL CLEARANCE LOADED	Uplinked clearance contains a fault *(in the simulator, this fault will never occur).*
PARTIAL ROUTE UPLINK	Uplinked route contains a fault and is partially rejected.
PERF/VNAV UNAVAILABLE	Pilot arms VNAV while gross weight, cost index, or cruise altitude is not entered.
PURGE UPDATES POS 2/3	DME reasonableness check failed *(in the simulator, this fault will never occur).*
RE-LOGON TO ATC COMM	ATC did not respond to logon *(in the simulator, this fault will never occur).*
RESET MCP ALT	Less than 2 minutes to go to T/D and MCP altitude is not below FMC cruise altitude.
RESYNC FAIL - SINGLE FMC	Resynchronization failure.
RESYNCING OTHER FMC	Resynchronization is in progress.
ROUTE () UPLINK LOADING	FMC is loading uplinked flight plan into route (1 or 2).
ROUTE () UPLINK READY	Uplinked flight plan is ready to be loaded into route (1 or 2).
RTA FIX DELETED	RTA fix is deleted from modified route.
RW/ILS CRS ERROR	Disagreement between selected ILS course and ILS course in approach procedure.
RW/ILS FREQ ERROR	Disagreement between selected ILS frequency and ILS frequency of selected approach procedure.
SET CLOCK TO UTC TIME	IRS position entered and pilot clock differs from GPS time by more than 12 seconds.

(continued next page)

FMC Scratchpad Messages: *(continued)*

High priority messages (accompanied by EICAS advisory)	
SINGLE FMC OPERATION	FMS operates with a single FMC.
SPLIT IRS OPERATION	Left and right FMC each uses a single IRU for position updating because an IRU fault occured or because FMS has changed to polar operation mode (>84° latitude).
THRUST REQUIRED	VNAV is engaged, aircraft is below planned descent path, A/T is off, and FMC requires higher thrust.
UNABLE FL... AT RTA FIX	The flight level indicated in the message cannot be reached at the RTA fix.
UNABLE NEXT ALT	VNAV is engaged and aircraft is unable to climb to next waypoint altitude constraint.
UNABLE RTA	Difference between RTA and predicted ETA exceeds allowable tolerance.
UNABLE TO LOAD CLEARANCE	Uplinked clearance data cannot be loaded *(in the simulator, this fault will never occur).*
UNABLE TO SEND MESSAGE	Downlink initiated, but not transferred to ACARS MU *(in the simulator, this fault will never occur).*
VERIFY POSITION	Disagreement between radio updated position and FMC position, or between positions of FMC L and R.
VERIFY RNP - POS REF 2/3	Default RNP has changed and now exceeds manually entered RNP.
WIND DATA UPLINK READY	Forecast wind and temperature data are uplinked and ready to be loaded.

FMC Scratchpad Messages:

Low priority messages (not accompanied by EICAS advisory)	
ARR N/A FOR RUNWAY	Selected arrival procedure is not applicable to selected runway.
CRS REVERSAL AT FA FIX	Final approach fix in route contains a course reversal without a course reversal procedure.
DELETE	DEL key has been pushed and line deletion is armed.
INVALID DELETE	Deletion of the selected line is not allowed.
INVALID ENTRY	Entered format or value is not allowed.
MAX ALT FL...	Entered cruise altitude is higher than maximum altitude of selected performance mode. Message indicates maximum altitude.
NOT IN DATABASE	Entered identifier is not in database.
NOT ON INTERCEPT HEADING	LNAV is armed and crosstrack error is greater than 2.5 nm and aircraft is not on an intercept heading to the active leg.
RESPOND TO ATC UPLINKS	Number of uplinks exceeds limit.
ROUTE FULL	Route modification exceeds the limit of 120 legs. Legs beyond the limit are not entered.
RUNWAY N/A FOR SID	Selected runway is not applicable to selected standard instrument departure procedure.
STANDBY ONE	FMC is busy for more than 6 seconds.
TIMEOUT - RESELECT	CDU has been disconnected from the last selected subsystem (from the FMC, for example). Reselection is possible when the subsystem is reconnected.
UNABLE CRZ ALT	Aircraft is unable to climb to the entered cruise altitude without falling below the minimum allowable cruise time.
VERIFY RNP ENTRY	Manually entered RNP exceeds default RNP.

EICAS Messages:

CAUTION MESSAGES (accompanied by caution light and beeper sound)		
>UNABLE RNP		required navigation performance (RNP) is higher than the actual (ANP) during GPS approach

ADVISORY MESSAGES		
FMC ()	FAIL LIGHT	FMC (LEFT or RIGHT) has failed
>FMC MESSAGE		either CDU contains at least one FMC generated high priority message
>UNABLE RNP		required navigation performance (RNP) is higher than the actual (ANP) during any flight phase other than GPS approach

MEMO MESSAGES		
ATC MESSAGE		at least one new uplink message has been received

STATUS MESSAGES		
CDU ()		CDU (LEFT, CENTER, or RIGHT) has failed
FMC ()	FAIL LIGHT	FMC (LEFT or RIGHT) has failed
WEIGHT/BALANCE		weight & balance computer system failure AND aircraft is on the ground

Fuel System

Text Conventions:

- *Center wing tank (CWT)* is shortened in this book to *center tank* because synoptics, messages, and most panel labels on the flight deck also refer to *center (CTR)* only. As there are no other tank designations referring to the center, term confusion will be unlikely.
- *Horizontal stabilizer tank (HST)* is shortened in this book to *stabilizer tank* because synoptics, messages, and panel labels on the flight deck also refer to *stabilizer (STAB)* only. As there is no tank in the *vertical* stabilizer, term confusion will be unlikely.

PNF

In the simulator, some pump and valve switches may be operated by the virtual Pilot Non-Flying (PNF) to relieve the flying pilot in a one-crew simulator session. The PNF can be deactivated on **Instructor** > **Situation** > **Human** > **Pilot** by clearing the checkbox **Performs silent tasks**.

System Overview:

The system supplies fuel to the APU and to the engines. Tanks are installed at various places inside the aircraft structure. To reduce wing bending and to keep the aircraft's center of gravity within an adequate range during fuel use, certain tanks are emptied earlier than others. For this purpose, a number of pumps and valves must be operated in a particular order. The operation is largely automatic. Also included is a semi-automatic fuel jettison system.

A Weights are indicated either by kilograms (KGS) or US pounds (LBS) as specified by the airline.

Defueling Panel:

A Toggle switch directions are aircraft specific; the OFF and CLOSE functions may be in the upper or in the lower position.

A **Center tank scavenge pump switch (guarded)**

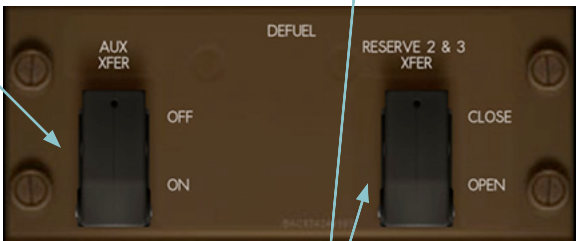
*(this switch is only installed on aircraft equipped with an **electric** scavenge pump)*

ON Pump is commanded to run.

A **Auxiliary tank transfer switch (guarded)**

(this switch is only installed on aircraft equipped with an auxiliary tank)

ON Fuel transfer is commanded to run.



Reserve 2 & 3 transfer switch (guarded)

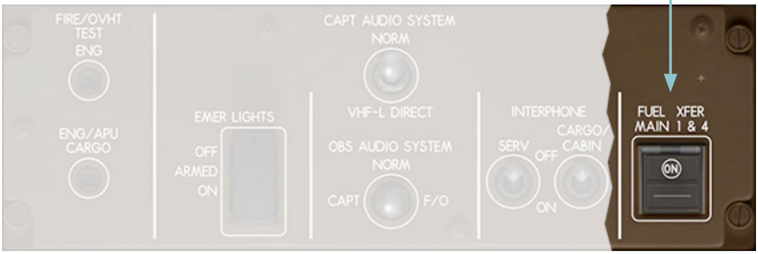
*(this switch is located in the middle of the panel if no **electric** scavenge pump and no auxiliary tank are installed)*

OPEN Valves are commanded to open.

Transfer and Jettison Panels:

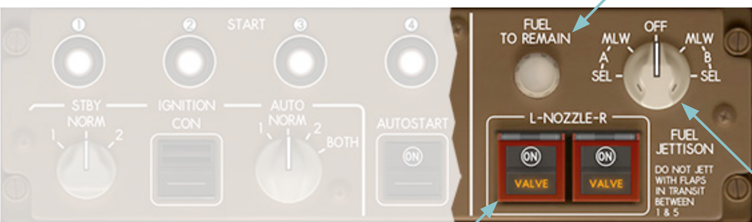
Transfer main 1 & 4 switch (guarded)

ON Valves are commanded to open to allow gravity transfer into main tanks 2 & 3.



Fuel-to-remain selector

Rotate Selects a total fuel value at which jettison will automatically stop. Value is indicated on EICAS when system is armed.



Jettison nozzle valve switches

ON Valve is commanded to open.

VALVE LIGHT Valve unpowered or position disagreement.

Jettison control selector

OFF System is disarmed.

A, B System is armed.

A **MLW** Fuel-to-remain is set for maximum landing weight.

Fuel Control Panel:

A Auxiliary transfer switches

ON Transfer activates when commanded by system.

PRESS LIGHT Low pressure or system disagreement.

Crossfeed valve switches 2 & 3 (guarded)

ON (bar in view) Valve opens when commanded by system logic.

VALVE LIGHT Valve unpowered or position disagreement.

Center tank pump switches

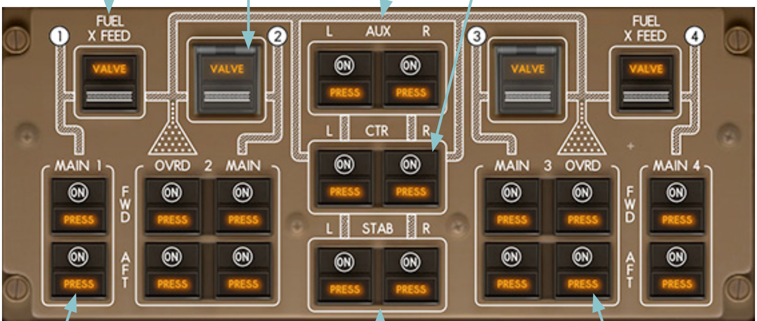
ON Pump is commanded to run.

PRESS LIGHT Low pressure or system disagreement.

Crossfeed valve switches 1 & 4

ON (bar in view) Valve is commanded to open.

VALVE LIGHT Valve unpowered or position disagreement.



Main tank pump switches

ON Pump is comman-ded to run.

PRESS LIGHT Low pressure.

A Stabilizer tank pump switches

ON Pump operates when comman-ded by system.

PRESS LIGHT Low pressure or system disagree-ment.

Override pump switches

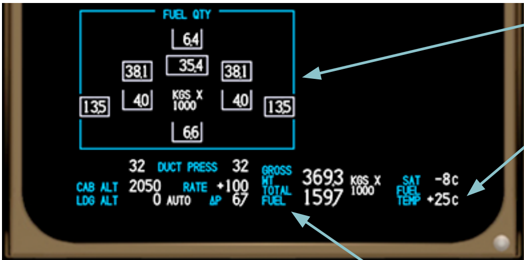
ON Pump operates when commanded by system.

PRESS LIGHT Low pressure.

EICAS Fuel Synoptics:

Fuel synoptic switch

First push	Shows fuel synoptic on secondary EICAS display if display is available; otherwise shows compacted quantity indications on primary EICAS display.
Second push	Removes fuel synoptic or compacted indications from EICAS displays.



Compacted quantity indications

Fuel temperature in °C

Total fuel quantity

Auxiliary tank transfer

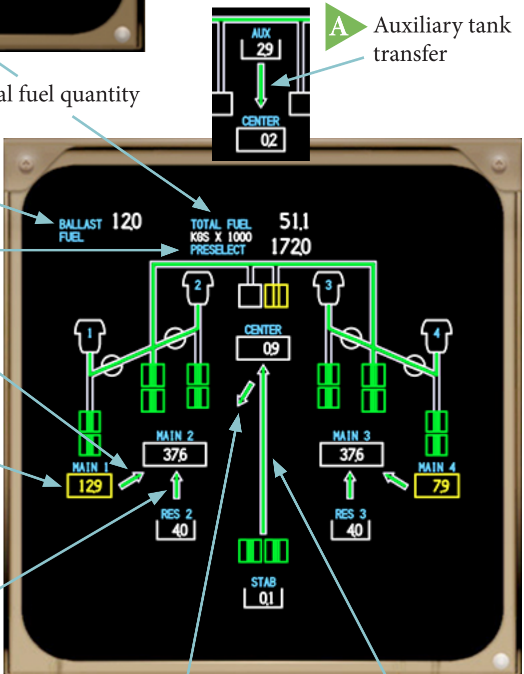
Fuel ballast

Refueling preselection

Main tank transfer

Tank quantity (amber when low fuel or imbalance)

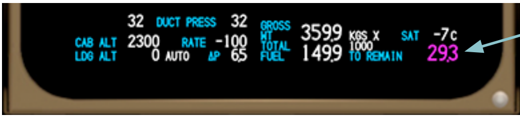
Reserve tank transfer



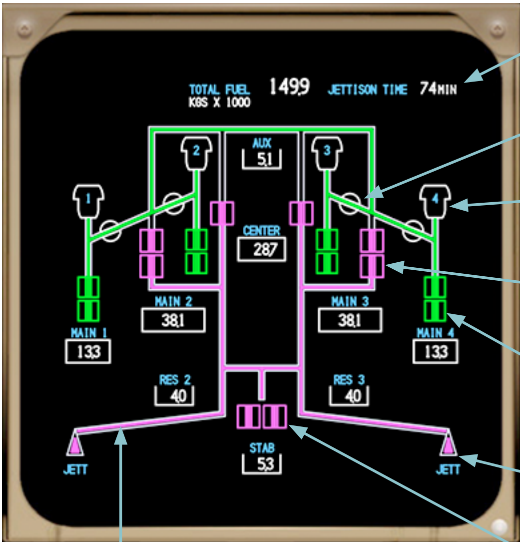
Electric scavenge transfer

Stabilizer tank transfer

EICAS Fuel Synoptics:



Fuel to remain (indicated when jettison system is armed)



Time until jettison is completed

Crossfeed valve

Engine

Override/jettison pump

Main tank pump

Jettison nozzle

Transfer/jettison pump

Fuel flow bar (based upon pump and valve states)

Flow bars:

Green	Normal fuel flow to engines
Amber	Suction feeding to engines
Magenta	Fuel flow to jettison nozzles
Blank	No fuel flow

Pump symbols:

Green	Pump on and producing pressure
Amber	Pump on and low pressure
Cyan	Pump in standby mode
White	Pump off

Engine symbols:

White	Normal fuel pressure
Amber	Suction feeding

Valve symbols:

White	Valve position agrees with commanded position
Amber	Valve position disagrees with commanded position

Fuel Pumps:

Main boost pumps are installed in all four main tanks. Each main boost pump is AC motor driven and provides sufficient fuel pressure to one engine during takeoff, or to two engines in cruise. If there is no pressure in the manifold, check valves automatically open, allowing fuel to bypass the inactive pumps so that the engines can suction the fuel from the tanks directly. However, suctioning alone cannot produce the same high fuel flow as the tank pumps can, hence thrust in the takeoff range is then no longer available.

Override/jettison pumps (O/J pumps) are installed in the inboard main tanks and in the center tank. Each O/J pump is driven by an AC motor and provides sufficient fuel to two engines in all flight phases. To ensure the inboard main tanks will not be completely emptied during jettison, the O/J pump inlets are located at a slightly higher point in these tanks; that is, the O/J pumps in an inboard main tank become inoperative at a standpipe level of ca. 3200 kg (7000 lb). The O/J pumps in the center tank stop operating at a standpipe level of ca. 900 kg (2000 lb).—The fuel pressure produced by the O/J pumps is greater than that of the main boost pumps; when main boost pumps and O/J pumps are powered at the same time, the fuel output of the main boost pumps is hydromechanically overridden so that only the O/J pumps provide fuel to the engines.—During jettison, the O/J pumps transfer fuel into the jettison manifold.

Older aircraft are equipped with an **electric scavenge pump** powered by AC bus 1. The electric scavenge pump starts automatically when any reserve tank transfer valve is open and no fuel ballast is required, or when low pressure is detected in one of the O/J pumps in the center tank. It can also be started manually with the CWT SCAVENGE PUMP switch on the maintenance panel. The electric scavenge pump transfers the remaining center tank fuel into main tank 2. This may lead to a faintly asymmetrical fuel distribution. However, aircraft fitted with an electric scavenge pump also use an older APU fuel feed system which connects the APU to main tank 2 only. Hence a slight imbalance in the opposite direction may already exist before the scavenging begins; the scavenging will then rebalance it.

In newer aircraft, four **hydromechanically driven jet pumps** are installed for scavenging the center tank. They pump the fuel symmetrically into main tanks 2 and 3. The system starts automatically when the center tank quantity decreases to ca. 1820 kg (4000 lb). Manual control is not possible. Aircraft fitted with this hydromechanical system also have a newer APU fuel feed system which supplies the APU symmetrically from main tanks 2 and 3.

(continued next page)

Fuel Pumps: *(continued)*

One **DC driven boost pump** in main tank 2 provides fuel to the APU. This pump is driven by the APU battery bus. When AC power is available, the DC pump shuts down and the APU is fed by main boost pump 2 AFT and—if a hydromechanical scavenge system is installed—also by main boost pump 3 AFT. The APU fuel feed system is fully automatic. The pumps operate when the APU is started.

Some aircraft have a stabilizer tank which contains two **transfer/jettison pumps**. These pumps are AC motor driven and can transfer all of the fuel in the stabilizer tank into the center tank when in normal flight, or into the jettison manifold during jettison.

Auxiliary Tank System:

Extended range (ER) aircraft models may be fitted with an auxiliary tank (AUX tank). The system is designed to take fuel from the refueling manifold during refueling, and to feed this fuel into the center tank later in cruise. There are no fuel pumps involved. The fuel transfer into the center tank is achieved solely by differential air pressure between the tanks. The AUX tank is pressurized with filtered cabin air; the required air flow is generated by the cabin pressure itself. Cabin air may be pressed into the tank also by an electrical blower system.

AUX transfer valves are installed for isolating the fuel outlet to the center tank. The valves are controlled automatically, or by the AUX XFER switch on the maintenance panel. In normal operations, the crew sets both AUX L and AUX R switches on the fuel panel to ON to arm the automatic transfer. When the transfer is completed, the crew sets the switches to OFF.

The control system has many safeguards to protect the tank from cabin fires. This includes isolation of the AUX tank any time the CARGO FIRE ARM FWD switch is set to ON.

Crossfeed Manifold and Valves:

The center tank and all main tanks are connected through a common fuel manifold. The manifold incorporates four crossfeed valves which can be used to set flight-phase-specific or malfunction-specific engine fuel feed configurations.

Reserve Tank Transfer Valves:

There are two transfer valves in each reserve tank allowing gravity transfer from the reserve tanks to the inboard main tanks. These valves are opened automatically when any inboard main tank quantity is less than ca. 18000 kg (40000 lb). They can also be opened manually with the RESERVE 2 & 3 XFER switch on the maintenance panel.

Main Tank Transfer Valves:

Each outboard main tank contains a transfer valve that allows gravity transfer from the outboard to the inboard main tank as long as the outboard quantity is higher than ca. 3200 kg (7000 lb). These valves open automatically during jettison when any inboard main tank quantity is less than ca. 9000 kg (20000 lb). They can also be opened manually with the FUEL XFER MAIN 1 & 4 switch on the overhead panel.

Fuel Temperature Indicating:

The fuel temperature is measured in main tank 1 only. The temperature is indicated on the primary EICAS display. Should the fuel temperature fall within 3°C of the freezing point of the fuel type in use, a warmer flight region (vertically or laterally) or a higher airspeed should be chosen as the wing skin temperature rises with airspeed.

(In the simulator, the fuel type to be modeled can be selected on ***Instructor > Situation > Service****.)*

Fuel Quantity Indicating:

The fuel quantity indicating system (FQIS) receives fuel volume signals from various sensors in the tanks. Some tanks also include densitometers and compensators. With the volume and density values the FQIS computes the fuel weight in each tank as well as the total fuel weight, and indicates the data on the EICAS. The data is blank when the FQIS is unpowered. It is powered when DC bus 3 or 4 is available, or when refueling is in progress.

(In the simulator, the fuel density varies randomly around a value very close to 0.8 kg/l.)

Refueling System:

A refueling control panel is installed on the left wing *(in the simulator, refueling controls are represented on the instructor's station)*. The panel provides means to preselect the desired total fuel quantity and to open the refuel valves. When the panel door is open, power is connected to the refueling system. The power source may be the main hot battery bus or the ground handling bus (GHB). In normal operations, the GHB is used; it is available when the APU is running or when external power is connected. The preselected quantity is displayed on the EICAS fuel synoptic. During refueling, when the on-board fuel quantity reaches the preselected limit, fuel loading stops automatically. It can be stopped manually as well.

*(In the simulator, controls for quantity preselection, starting, and stopping are represented on **Instructor** > **Situation** > **Service**. The Service page also provides edit fields for direct fuel entries to bypass the refueling time completely. A flexible time acceleration control is available on **Instructor** > **Situation** > **Time**. The fuel slider on **Instructor** > **Situation** > **Aerodynamics** is another tool for changing the total fuel quantity.)*

Defueling System:

Refueling stations at the wings can also be used for defueling on the ground.

*(In the simulator, the defueling switches on the maintenance panel are fully functional for aircraft internal fuel transfers, but real-time defueling into an external tank is not possible. Quantities can be promptly reduced on **Instructor** > **Situation** > **Service** or with the fuel slider on **Instructor** > **Situation** > **Aerodynamics**.)*

Vent and Surge:

A vent and surge system is included to protect the aircraft structure against overfueling or fuel expansion. Overpressure in tanks is directed through vent lines into surge tanks. There is a surge tank in each wing tip and one on the right side of the stabilizer tank. Air from these tanks—and in abnormal cases also excess fuel—are vented overboard.

Fuel Jettison:

Jettison relevant pumps and valves are automatically controlled by one of the two fuel jettison control cards (FJCCs), labeled as A and B. Setting the jettison selector to A or B replaces the temperature indication on the EICAS by a magenta fuel-to-remain value. This value can be adjusted by the FUEL TO REMAIN selector on the overhead panel. Some aircraft are equipped with a jettison selector that provides another position labeled as MLW. When MLW is selected, the FUEL TO REMAIN selector is disabled and the fuel-to-remain quantity is set so that the resultant gross weight is equal to the maximum landing weight. Jettison finally begins when at least one of the two nozzle valve switches are set to ON.

The estimated jettison time is displayed on the EICAS. The FJCC monitors the fuel balance in the inboard main tanks. Should an imbalance occur, the O/J pumps in the lighter tank are automatically deactivated until the quantities are rebalanced. When the total fuel quantity reaches the preselected fuel-to-remain quantity, the fuel-to-remain indication turns white and flashes for five seconds, and the FJCC shuts down all jettisoning pumps. The procedure is completed when the crew sets the nozzle valve switches and the jettison selector to OFF.

Fuel Ballast:

The combi aircraft model is equipped with a ballast alert system. With passengers in the forward section and cargo in the aft section, the combi is more prone to being tail-heavy than other models. This may become particularly apparent when the center tank quantity decreases during the flight. As the center tank is located forward of the aerodynamic center, it may be necessary to keep a certain minimum quantity in this tank as a counter weight to the aft cargo. The crew may enter a ballast value on the FMC PERF INIT page. This value will also be displayed on the EICAS fuel synoptic. When the center tank quantity decreases to this value, the EICAS caution message >FUEL BALLAST appears to remind the crew to set both center tank pumps to OFF. To enable the alert, all of the following conditions must be true:

+ FQIS is operative
+ Both FMCs are operative
+ FMC totalizer fuel is indicated
+ FMC calculated fuel is indicated

EICAS Interface:

The fuel system EICAS interface cards (FSEICs) collect data from various subsystems and feed them into the EICAS for use in generating messages and synoptics. There is a master FSEIC and a slave FSEIC; both cards are powered by DC bus 3. When unpowered, fuel related messages are disabled and the flow bars on the fuel synoptic are removed.

Engines Fuel Feed Operation:

Two fuel system management cards (FSMCs) automatically control the valves and pumps during the flight according to a preprogrammed schedule. In addition, some manual actions are required as shown on the tank operation tables below and on the next two pages.

The system management of the center and stabilizer tank pumps was modified in 2003. The modification affects EICAS messages and crew actions. The goal is to make sure the pumps are deactivated whenever their inlets are not completely covered by fuel. This may be the case when the fuel level is very low, or when the level is tilted due to steep aircraft pitch attitudes or high acceleration during takeoff. Fuel vapor located outside the liquid fuel mass may explode when it comes in contact with a damaged pump. Also relevant to the deactivation timing is the fact that the fuel quantity indicating system lags behind the true quantity by several minutes. The modified system management takes all these parameters into account.

When in climb, the EICAS advisory messages >FUEL OVD CTR () and >FUEL PMP STB () are inhibited. The inhibit ends when the aircraft pitch has been below 5° for 10 minutes.

A *Auxiliary Tank Operation:*

Stage	**Required crew action**	**Result**
AUX tank is full.	Set both AUX switches to ON	System is armed.
stabilizer tank quantity at 230 kg (500 lb) OR { at 1100 kg (2500 lb) AND stab pumps switched off }	-	FSMCs activate transfer from auxiliary tank to center tank.
AUX tank below 230 kg (500 lb). EICAS message: >FUEL AUX ().	Set both AUX switches to OFF	Transfer stops.

Center Tank Operation:

If the center tank contains less than 1800 kg (4000 lb) before engine start, the center tank pumps must remain off on the ground and through the entire flight. Otherwise, center tank pump operation will be allowed under the respective conditions A, B, or C:

Condition **A** **1800 - 7600 kg (4000 - 16900 lb)** in center tank before engine start:

Stage	EICAS message	Required crew action
		Set both pump switches to OFF [1]
Cruise begins	>FUEL OVD CTR ()	Set both pump switches to ON
At ~1300 kg (3000 lb)	>FUEL LOW CTR ()	Set both pump switches to OFF

[1] If the pumps were to run from engine start on, beginning at a quantity below 7700 kg (17000 lb), the quantity might decrease to the climb-attitude-specific limit of 3200 kg (7000 lb) already shortly after takeoff. Reaching that limit in climb would require the crew to switch the pumps off. To relieve the crew during this high-workload flight phase, the center tank pumps must remain off from start until cruise.

Condition **B** **7700 - 22600 kg (17000 - 49900 lb)** in center tank before engine start:

Stage	EICAS message	Required crew action
		Set both pump switches to ON
At ~3200 kg (7000 lb) in climb	>FUEL LOW CTR ()	Set both pump switches to OFF [2]
Cruise begins	>FUEL OVD CTR ()	Set both pump switches to ON
At ~1300 kg (3000 lb)	>FUEL LOW CTR ()	Set both pump switches to OFF

[2] This effect is only possible if the aircraft pitch is above 5°.

Condition **C** **At least 22700 kg (50000 lb)** in center tank before engine start:

Stage	EICAS message	Required crew action
		Set both pump switches to ON
At ~1300 kg (3000 lb)	>FUEL LOW CTR ()	Set both pump switches to OFF

The initial quantity of 22700 kg (50000 lb) is so high that it cannot decrease to the critical minimum before the cruise begins, hence the above items [1] and [2] are irrelevant in this case.

When the center tank pumps shut down, the FSMCs activate the O/J pumps in main tanks 2 and 3, so that main tank 2 supplies the left wing engines, and main tank 3 supplies the right wing engines.

A *Stabilizer Tank Operation:*

If the stabilizer tank contains less than 3000 kg (6600 lb) before engine start, the stabilizer tank pumps must remain off on the ground and through the entire flight. If the stabilizer tank contains at least 3000 kg (6600 lb) before engine start, stabilizer tank pump operation will be allowed when the aircraft has reached the cruise altitude. During climb, the stabilizer tank pumps must remain off. In cruise, the FSMCs will activate the stabilizer tank pumps when the associated switches are set to ON and the center tank has decreased to 36500 kg (80000 lb).

Stabilizer tank pump operation in **cruise**:

EICAS quantity indication	EICAS message	Required crew action
More than 1600 kg (3600 lb)	>FUEL PMP STB L	Set left pump switch to ON
More than 1000 kg (2300 lb)	>FUEL PMP STB R	Set right pump switch to ON
Less than 1200 kg (2600 lb)	>FUEL LO STAB L	Set left pump switch to OFF
Less than 600 kg (1300 lb)	>FUEL LO STAB R	Set right pump switch to OFF

When the EICAS quantity indication is passing 600 kg (1300 lb), the true quantity is already in a range between 200 kg (500 lb) and zero.

Wing Tank Operation:

Stage	Required crew action	Result
Before engine start and all tanks full.	Set all valve switches, main pump switches, and main tank O/J pump switches to ON.	When flaps are extended: FSMCs close crossfeed valves 2 & 3. O/J pumps in main tanks 2 & 3 supply engines 2 & 3; main tank pumps 1 & 4 supply engines 1 & 4. When flaps are retracted: FSMCs open crossfeed valves 2 & 3. Center tank pumps supply all engines.
Main tank 2 or 3 quantity decreased to 18100 kg (40000 lb).	-	FSMCs activate transfer from reserve tanks 2 & 3 to associated main tanks, and start center tank scavenging.
Inboard main tank quantities are equal to or less than outboard main tank quantities. EICAS message: FUEL TANK/ENG.	Confirm tank quantities. Set main tank O/J pump switches to OFF. Set valve switches 1 & 4 to OFF.	Main tank pumps provide fuel to their associated engines until engine shutdown.

EICAS Messages:

	CAUTION MESSAGES (accompanied by caution light and beeper sound)		
A	>FUEL BALLAST		any center tank pump producing pressure AND center tank quantity not higher than ballast
A	FUEL BALLAST QTY		any center tank pump switch on AND current ballast value differs from previous value by 90 kg (200 lb) or more *[message inhibited for 60 sec after flight completion]*
A	FUEL BALLAST SYS		any center tank pump switch on AND ballast logic contains disagreeing or invalid data
	FUEL JETT SYS		both jettison systems fail OR { jettison system armed AND any nozzle valve open AND total fuel less than fuel-to-remain value }
A	FUEL PRES STAB L	PRESS LIGHT	{ left stabilizer tank pump low pressure AND stabilizer tank transfer valve open } OR { left stabilizer tank pump switch on AND stabilizer tank at critical limit for 30 sec } *[critical limit is 3600 kg (8000 lb) when pitch is above 5°, else 1200 kg (2600 lb)]*
A	FUEL PRES STAB R	PRESS LIGHT	{ right stabilizer tank pump low pressure AND stabilizer tank transfer valve open } OR { right stabilizer tank pump switch on AND stabilizer tank at critical limit for 30 sec } *[critical limit is 3600 kg (8000 lb) when pitch is above 5°, else 600 kg (1300 lb)]*
	FUEL PRESS ENG ()	PRESS LIGHT	low pump pressure in main tank (1, 2, 3, or 4) AND associated crossfeed valve closed
	FUEL QTY LOW		any main tank quantity below 900 kg (2000 lb)
A	FUEL STAB XFR		stabilizer tank transfer status disagrees with system command

EICAS Messages:

	ADVISORY MESSAGES		
A	>FUEL AUX ()	PRESS LIGHT	auxiliary tank transfer switch (L or R) is on AND auxiliary tank quantity below 230 kg (500 lb)
	>FUEL IMBAL 1-4		difference greater than 1360 kg (3000 lb) between main tanks 1 and 4 *[message disappears when difference decreases below 450 kg (1000 lb)]*
	>FUEL IMBAL 2-3		difference greater than 2720 kg (6000 lb) between main tanks 2 and 3 *[message disappears when difference decreases below 450 kg (1000 lb)]*
	>FUEL IMBALANCE		difference greater than 1360 kg (3000 lb) between inboard and outboard main tanks after reaching tank-to-engine condition *[message disappears when difference decreases below 450 kg (1000 lb)]*
	>FUEL JETT ()		jettison system (A or B) inoperative
A	>FUEL LO STAB L	PRESS LIGHT	left stabilizer tank pump switch on AND stabilizer tank at critical limit *[critical limit is 3600 kg (8000 lb) when pitch is above 5°, else 1200 kg (2600 lb)]*
A	>FUEL LO STAB R	PRESS LIGHT	right stabilizer tank pump switch on AND stabilizer tank at critical limit *[critical limit is 3600 kg (8000 lb) when pitch is above 5°, else 600 kg (1300 lb)]*
	>FUEL LOW CTR ()	PRESS LIGHT	center tank pump (L or R) running AND center tank at critical limit *[critical limit is 7700 kg (17000 lb) when on ground, else 3200 kg (7000 lb) when pitch is above 5°, else 1300 kg (3000 lb)]*
	FUEL OVRD () AFT	PRESS LIGHT	aft override pump (2 or 3) low pressure when commanded on OR pump switched off while main tank quantities not equal
	FUEL OVRD () FWD	PRESS LIGHT	forward override pump (2 or 3) low pressure when commanded on OR pump switched off while main tank quantities not equal

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EICAS Messages:

(continued)

	ADVISORY MESSAGES		
	FUEL OVD CTR ()	PRESS LIGHT	{ center tank pump (L or R) switch on AND pump low pressure } OR { switch off AND tank quantity not at critical limit } *[critical limit is 7700 kg (17000 lb) when on ground, else 1800 kg (4000 lb) when pitch has been below 5° for 10 minutes, else fuel ballast value if any entered, else not-at-critical-limit alert is inhibited in climb]*
A	>FUEL PMP STB L	PRESS LIGHT	{ left stabilizer tank pump switch on AND { aircraft on ground OR left pump low pressure } } OR { switch off AND pitch below 5° for 10 minutes AND tank at or above 1600 kg (3600 lb) }
A	>FUEL PMP STB R	PRESS LIGHT	{ right stabilizer tank pump switch on AND { aircraft on ground OR right pump low pressure } } OR { switch off AND pitch below 5° for 10 minutes AND tank at or above 1000 kg (2300 lb) }
	FUEL PUMP () AFT	PRESS LIGHT	aft main tank pump (1, 2, 3, or 4) low pressure *[message inhibited by FUEL PRESS ENG ()]*
	FUEL PUMP () FWD	PRESS LIGHT	forward main tank pump (1, 2, 3, or 4) low pressure *[message inhibited by FUEL PRESS ENG ()]*
	FUEL RES XFR ()		reserve tank (2 or 3) transfer valves closed while commanded open
	>FUEL TANK/ENG		inboard main tank quantity at or below outboard main tank quantity AND crossfeed valve 1 or 4 open
	>FUEL TEMP LOW		fuel temperature below -37°C
	>FUEL TEMP SYS		fuel temperature indicating system inoperative
	FUEL X FEED ()	VALVE LIGHT	fuel crossfeed valve (1, 2, 3, or 4) disagrees with commanded position

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EICAS Messages:

(continued)

	ADVISORY MESSAGES		
	>FUEL XFR 1+4		main tank 1+4 transfer switch on AND { aircraft on ground OR inboard quantities greater than outboard quantities }
	>JETT NOZ ON		left and right nozzle valves open
	>JETT NOZ ON ()		nozzle valve (L or R) open *[message inhibited by >JETT NOZ ON]*
	>JETT NOZZLE ()	VALVE LIGHT	nozzle valve (L or R) disagrees with commanded position
A	>SCAV PUMP ON		electric scavenge pump manually switched on
	>X FEED CONFIG		{ crossfeed valve 1 or 4 closed AND main tank quantities not equal } OR { crossfeed valve 2 or 3 closed AND flaps not in takeoff position }

	STATUS MESSAGES		
	FSEIC		fuel system EICAS interface card failure OR data bus failed
	FSMC ()		fuel system management card (A or B) failure OR data bus failed
A	FUEL BALLAST SYS		invalid FQIS center tank quantity value AND valid fuel ballast value from any FMC
	FUEL JETT ()		jettison system (A or B) inoperative
	FUEL OVRD () AFT	PRESS LIGHT	aft override pump in tank (2 or 3) low pressure AND tank quantity above 4500 kg (10000 lb)
	FUEL OVRD () FWD	PRESS LIGHT	forward override pump in tank (2 or 3) low pressure AND tank quantity above 4500 kg (10000 lb)
	FUEL OVRD CTR ()	PRESS LIGHT	center tank pump (L or R) low pressure AND center tank quantity above 2700 kg (6000 lb)
A	FUEL PMP STAB ()	PRESS LIGHT	stabilizer tank pump (L or R) low pressure AND tank quantity above 1100 kg (2500 lb)

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EICAS Messages:

(continued)

STATUS MESSAGES		
FUEL PUMP () AFT	PRESS LIGHT	aft main tank pump (1, 2, 3, or 4) low pressure AND main tank pump switch on
FUEL PUMP () FWD	PRESS LIGHT	forward main tank pump (1, 2, 3, or 4) low pressure AND main tank pump switch on
FUEL QTY SYS		fuel quantity indicating system failure OR input inoperative OR data output bus failed
FUEL TEMP		fuel temperature indicating system inoperative
FUEL X FEED ()	VALVE LIGHT	fuel crossfeed valve (1, 2, 3, or 4) disagrees with commanded position OR valve unpowered *[message inhibited when on ground while thrust above idle]*
FUEL XFR VLV ()		main tank (1 or 4) transfer valve position disagrees with commanded position OR valve unpowered
JETT NOZZLE ()	VALVE LIGHT	nozzle valve (L or R) disagrees with commanded position OR valve unpowered
JETT XFR VALVE		any jettison transfer valve disagrees with commanded position OR valve unpowered
RES () XFR VLV		reserve tank transfer valve (2A, 2B, 3A, or 3B) disagrees with commanded position OR valve unpowered
A STAB XFR VLV		any stabilizer transfer valve disagrees with commanded position OR valve unpowered

Limitations in the Simulator:

There are no auxiliary tank related messages modeled other than >FUEL AUX L and >FUEL AUX R.—Also, message relevant malfunctions of the center tank refuel valve, the electric scavenge pump, engine fuel spar valves, and main tank volume signals cannot occur, hence the related status messages CTR REFUEL VLV, FUEL SCAV PUMP, FUEL SPAR VLV (), M2/M3 <3K SIG, and M2/M3 <6K SIG are not modeled.

Hydraulics

System Overview:

Four hydraulic systems—all independent of each other—power various flight controls, landing gear controls, and autopilot servos. Every system can generate hydraulic pressure by an **engine driven pump (EDP)** or by a **demand pump**, or by both. A third pump, called **auxiliary pump**, is incorporated in system 4, optionally also in system 1. All pumps within a system are installed in parallel and are supplied with hydraulic fluid by a common fluid reservoir. To assure a positive fluid supply to the pumps, the reservoirs themselves are pressurized pneumatically: the reservoirs in systems 1 and 2 are pressurized by the left bleed air duct, and those in systems 3 and 4 by the right bleed air duct. The standpipes supplying the pumps from the reservoir are installed at different reservoir levels. The standpipe for the EDP and auxiliary pump is dry when the fluid quantity is below circa 32%; the standpipe for the demand pump is dry when below approximately 5%.

Each EDP is mechanically driven by the respective engine's accessory gearbox. In case of an engine failure in flight, with the N2 (or N3) rotor windmilling, the EDP can maintain useable hydraulic pressure as long as the associated flight controls are not in permanent, impulsive motion. When the N2 (or N3) rotor shaft is stuck—due to a foreign object damage (FOD), for example—or if the fluid supply to the EDP is shut off due to the engine fire switch being pulled, the EDP will stop providing hydraulic pressure.

Demand pumps 1 and 4—optionally also 2 and 3—are **air driven pumps (ADPs)**. ADPs 1 and 2 are pressurized by the left bleed air duct, and ADPs 3 and 4 by the right bleed air duct. On some aircraft, demand pumps 2 and 3 are **AC motor driven pumps (ACMPs)**; ACMP 2 is powered by AC bus 2, and ACMP 3 by AC bus 3.

The auxiliary pumps are AC motor driven, powered by the ground handling bus (GHB). The GHB is powered when the AVAIL or ON light illuminates in the EXT-PWR-1 or APU-GEN-1 switch. The auxiliary pumps are only used for ground operations.

Each hydraulic system includes a **hydraulic interface module (HYDIM)**. A HYDIM receives signals from various switches and sensors; it includes the control logic for the demand pump and auxiliary pump; and it provides pressure, temperature, fault, and other data to the flight deck and maintenance indications.

The **hydraulic quantity interface module (HYQUIM)** receives signals from quantity transmitters installed in the four reservoirs, and provides the data to the flight deck and maintenance indications.

Overhead Panel:

Demand & auxiliary pump selector

AUX (System 4 A and system 1)
Deactivates the associated demand pump. Enables the auxiliary pump to activate automatically when the aircraft is on the ground and the respective EDP pressure is low.

OFF Deactivates the demand pump and auxiliary pump.

AUTO Enables the demand pump to activate automatically in any of the following cases:

- Associated EDP pressure is low.
- Associated engine is shut down.
- (System 1 & 4) Trailing edge flaps are in transit.
- A (System 1 & 4) Trailing edge flaps are out of up when airborne.

ON Activates the demand pump.

System fault light
Illuminates when the hydraulic system pressure or reservoir quantity is low, or when the hydraulic fluid temperature is excessive.

Demand pump low pressure light
Illuminates when the hydraulic demand pump pressure is low.

EDP switch

ON Enables the EDP to pressurize the system when the respective engine's N2 (or N3) shaft rotates.

PRESS LIGHT EDP output pressure is low.

EICAS Status Display:

Status display switch

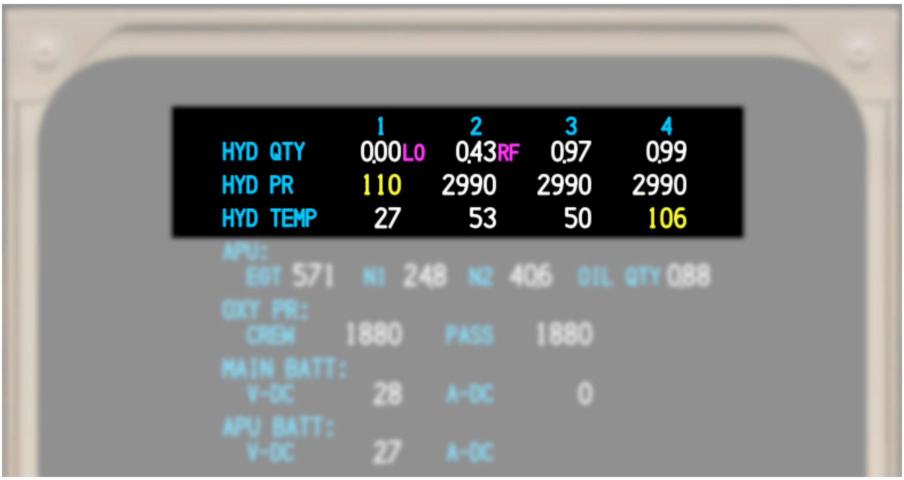
First push Shows status display with hydraulic indications on secondary EICAS display.

Second push Blanks secondary EICAS display.

HYD QTY—indicates the hydraulic reservoir fluid quantity of each system. 1.0 is the normal service level. RF (refill) is displayed when the level is below 0.75 and the aircraft is on the ground; LO (low) is displayed when the level is below 0.34; OF (overfilled) is displayed when the level is above 1.15.

HYD PR—indicates the hydraulic output pressure of each system in psi units. The value is shown in amber when the pressure is below 1400 psi and the associated engine is not shut down.

HYD TEMP—indicates the hydraulic fluid temperature of each system in °C. The value is shown in amber when the temperature rises above 105°C.



EICAS Hydraulic Synoptic:

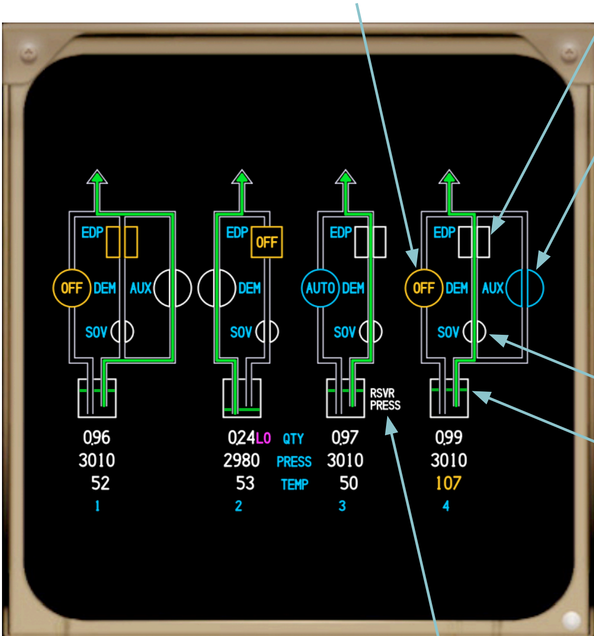
Hydraulic synoptic switch

First push Shows hydraulic synoptic on secondary EICAS display.

Second push Blanks secondary EICAS display.

Demand pump (OFF is shown when selector is set to OFF; green flow bar is shown when pressure is normal; amber bar is shown when selector is set to ON and pressure is low; AUTO is shown in amber when selector is set to AUTO and pump is commanded to run and pressure is low; AUTO is shown in cyan when selector is set to AUTO and pump is commanded to stop).

EDP (OFF is shown when selector is set to OFF; green flow bar is shown when pressure is normal; amber bar is shown when selector is set to ON and pressure is low).



Auxiliary pump (OFF is shown in white when selector is not set to AUX; green flow bar is shown when pressure is normal; cyan bar is shown when selector is set to AUX and pump is commanded to stop; amber bar is shown when pump is commanded to run and pressure is low).

Shutoff valve (shows open or closed position).

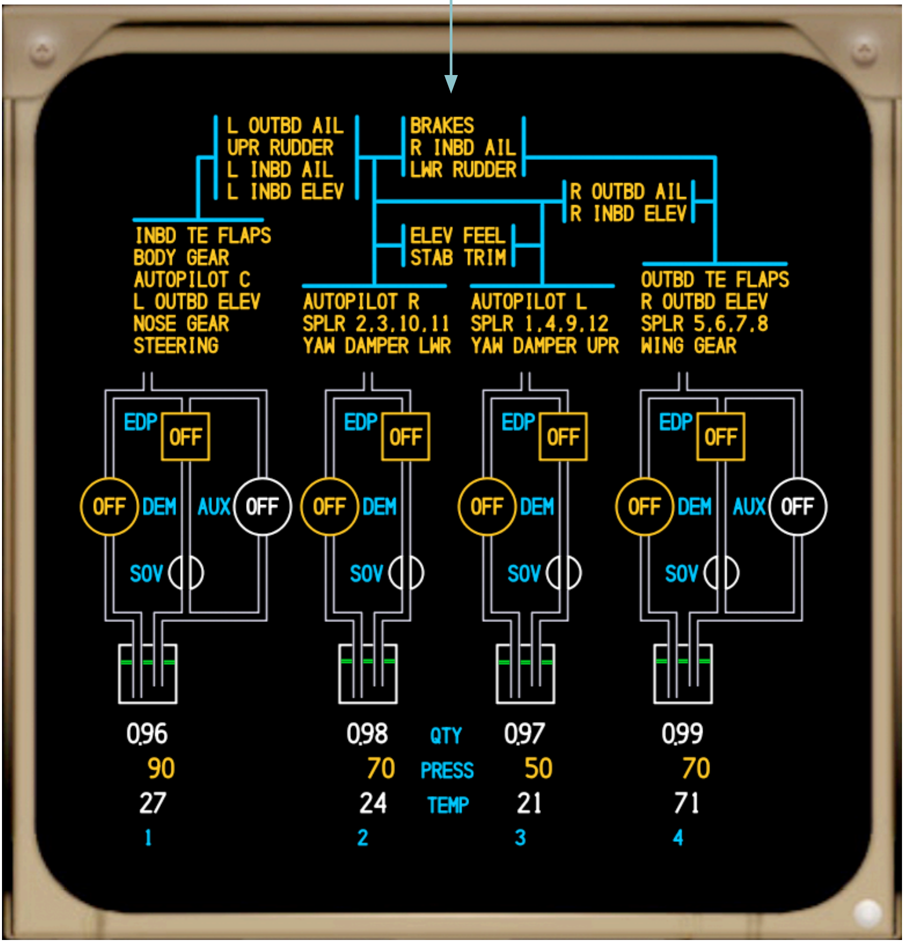
Reservoir fluid level.

RSVR PRESS message is shown when reservoir bleed air pressure is low.

Hydraulic power flow is indicated in green. The flow computation is just based on valve, pump, and fluid level data; hence, it is not assured that it always agrees with the actual power flow.

EICAS Hydraulic Synoptic:

A **Lists of disabled systems**
When low pressure is detected in a hydraulic system, a list appears above that hydraulic system, showing which autopilot and which flight and gear controls are disabled. The lists include thrust reversers if PW engines are installed.



Hydraulic System Distribution:

System 1	System 2	System 3	System 4
	Spoilers 2, 3, 10, 11	Spoilers 1, 4, 9, 12	Spoilers 5, 6, 7, 8
Aileron outboard L	Aileron outboard L	Aileron outboard R	Aileron outboard R
Aileron inboard L		Aileron inboard L	
	Aileron inboard R		Aileron inboard R
Flaps TE inboard			Flaps TE outboard
	Stabilizer trim	Stabilizer trim	
	Elevator feel	Elevator feel	
Elevator outboard L			Elevator outboard R
Elevator inboard L	Elevator inboard L	Elevator inboard R	Elevator inboard R
Rudder upper		Rudder upper	
	Rudder lower		Rudder lower
	Yaw damper lower	Yaw damper upper	
Autopilot C	Autopilot R	Autopilot L	
Gear actuation nose			Gear actuation wing
Gear actuation body			
Gear steering			
Brakes alternate	Brakes alternate		Brakes normal
PW engines only:			
A Thrust reverser 1	Thrust reverser 2	Thrust reverser 3	Thrust reverser 4

EICAS Messages:

CAUTION MESSAGES (accompanied by caution light and beeper sound)		
HYD PRESS SYS ()	SYS FAULT LIGHT	output pressure of hydraulic system (1, 2, 3, or 4) is below 1200 psi *[message inhibited by ENG () SHUTDOWN]*

ADVISORY MESSAGES		
HYD CONTROL ()		HYDIM (1 or 4) fails to provide automatic demand pump control and system data for indications
HYD OVHT SYS ()	SYS FAULT LIGHT	case drain temperature of any pump in hydraulic system (1, 2, 3, or 4) is above 105°C
HYD PRESS DEM ()	PRESS LIGHT	in hydraulic system (1, 2, 3, or 4) the demand pump selector is set to OFF OR demand pump is not powered OR { demand pump is commanded to run AND pump output pressure is below 1400 psi } OR { auxiliary pump is commanded to run AND pump output pressure is below 1400 psi } *[message inhibited by HYD PRESS SYS ()]*
HYD PRESS ENG ()	PRESS LIGHT	EDP (1, 2, 3, or 4) output pressure is below 1400 psi AND engine is not shut down *[message inhibited by HYD PRESS SYS ()]*
>HYD QTY LOW ()	SYS FAULT LIGHT	fluid quantity of hydraulic system (1, 2, 3, or 4) is at or below 0.34

STATUS MESSAGES		
HYD OVHT SYS ()	SYS FAULT LIGHT	case drain temperature of any pump in hydraulic system (1, 2, 3, or 4) is above 105°C
HYD PRESS DEM ()	PRESS LIGHT	in hydraulic system (1, 2, 3, or 4) the demand pump is commanded to run AND pump output pressure is below 1400 psi AND demand pump is powered AND associated engine is not shut down
HYD PRESS ENG ()	PRESS LIGHT	EDP (1, 2, 3, or 4) output pressure is below 1400 psi AND engine is not shut down
HYD RSVR PRESS ()		reservoir bleed air pressure of system (1, 2, 3, or 4) is at or below 21 psi
HYDIM ()		HYDIM (1, 2, 3, or 4) data bus has failed

Ice & Rain Protection

System Overview:

Ice detection

(Normally, installed on just some aircraft; and if installed, it is either a single or a dual probe system. In the simulator, all aircraft are equipped with a dual probe system.) Two ice detector probes are installed externally on the forward fuselage; one on the left, and one on the right side. The tip of each probe vibrates at 40 kHz by magnetostrictive effects, driven by an electric coil. When ice builds up on the tip, the frequency decreases. When the frequency has dropped to a certain limit, a heater activates and melts the ice. When the frequency has returned to 40 kHz, the heater deactivates and allows the tip to build up ice again. These cycles are repeated as long as icing conditions exist, and the system counts these cycles. In non-severe icing conditions, the heater will melt the ice in circa 10 seconds. In severe icing, the melting process will take more than 15 seconds; such long cycles will be counted as 2 cycles. Automatic anti-ice on the nacelles activates after 2 counted cycles, and that on the wings after 10, provided the respective automatic control is installed and enabled. When the tip has been vibrating at 40 kHz for 3 minutes, the counter is reset to zero, and all automatic anti-ice operation is terminated. When the aircraft is on the ground, the system will cycle also and melt the ice on the tip, but the counter will be locked at zero to prevent automatic anti-ice activation on the ground.

Probe heat

The aircraft is equipped with 2 total air temperature (TAT), 4 pitot-static (P/S), and 2 angle of attack (AOA) probes; engine specific probes are installed in the nacelles. All probes are electrically heated to prevent ice formation. There are no flight deck controls for probe heat aside from circuit breakers. Heat for the TAT probe is automatically activated when in flight. Heat for P/S, AOA, and engine internal probes is automatically activated when any engine is running in flight or on the ground.

Water line and waste drain heat

Electric heaters powered by 115 V AC protect all water systems on the aircraft against icing.

Windows

All flight deck windows are fitted with interior anti-fog systems. The forward windows also include exterior anti-fog and anti-ice systems. All systems use electric heat which is automatically modulated. The side window systems are powered whenever AC power is available; the front window systems require the WINDOW HEAT switches on the overhead panel to be set to ON.—The pilots can activate windshield defogging air by switches on the auxiliary panels *(in the simulator not shown)*.—Controls for windshield wipers and washers are available on the overhead panel.

(continued next page)

System Overview: *(continued)*

Wing and nacelle anti-ice

The wing leading edges and the engine nacelles can be protected against ice by hot bleed air that is directed through various spray ducts. For EICAS flags and synoptics refer to chapter **Power Plant** and chapter **Air Systems**.

PNF

In the simulator, the anti-ice switches may be set to ON and OFF by the virtual Pilot Non-Flying (PNF), according to the present icing conditions. The PNF can be deactivated on **Instructor** > **Situation** > **Human** > **Pilot** by clearing the checkbox **Performs silent tasks**.

SYSTEM ANALYSIS

In the simulator, ice accumulation is indicated on **Instructor** > **Analysis** > **Miscellaneous**: **Ice pAL;pAR;pCp;pFo** refers to the probes aux L, aux R, captain, first officer. The letter **c** indicates the probe is closed. **Ice wL;wR;n1;n2;n3;n4** refers to wing L, R, and nacelles 1 to 4. When free of ice, **0** is indicated. These strings are also accessible through the network.

Icing conditions can be set on **Instructor** > **Situation** > **Weather** using the temperature, cloud, visibility, and precipitation controls for the active weather zone. Icing occurs when all of the following conditions are true:

+ OAT is above -40°C.
+ TAT is below 3°C, or—if IAS is above 100 kt—below 9°C.
+ Aircraft is within cloud, fog, or precipitation.

Airport service simulations can be controlled on **Instructor** > **Situation** > **Service**:

- The **De-ice** button removes all ice from the wings, nacelles, and probes (but does not repair pitot leaks or ash clogging). The button may be used also when the aircraft is in flight.
- The slider under **Anti-ice fluid holdover time** simulates anti-ice fluid sprayed onto the aircraft by the airport service. The holdover time can be set to a value up to 45 minutes. A typical value is 15 minutes. The slider will automatically move towards zero, minute by minute. As long as the fluid holdover time is greater than zero, ice will *not* build up on the aircraft. The time control is disabled when the aircraft is in flight.

Window Systems:

Window heat switch

ON Powers the heat system for the respective front window when AC power is available.

OFF Removes power from the respective front window heat system. Leaving the switch in the OFF position for 10 seconds will reset any existing heat controller faults for the respective front window.

INOP LIGHT Heat controller fault, overheat, or power loss is detected.

Wiper switch

OFF Commands the wiper on the respective windshield to move to the stowed position, then removes power from the wiper system.

INT *(Normally an optional feature; in the simulator installed on all aircraft).* Activates the intermittent mode on the respective windshield. The wiper will cycle approximately every 7 seconds.

LO The wipers operate at low speed (circa 40 cycles per minute).

HI The wipers operate at high speed (circa 125 cycles per minute).

Washer switch

ON (momentary action) As long as the switch is held in the ON position, sprays washer fluid onto the associated windshield. The crew should remove the fluid by activating the respective wiper.

A The toggle ON functions may be in the upper or in the lower position.

Anti-Ice A *with Automatic Control:*

Nacelle anti-ice switch

ON Enables the respective engine‘s nacelle anti-ice valve to open. The valve requires bleed air pressure to move to the open position (during engine start, the pressure may be too low to open the valve). A green NAI flag is shown next to the associated N1 tape on the primary EICAS. The thrust idle-limit increases to approach-idle.

A *GE engines:*
Both igniters operate continuously.

A *PW engines:*
The manually or automatically selected igniters operate continuously.

A *RR engines:*
Igniters operate when an engine failure is detected (auto-relight), or when manually activated.

AUTO Same function as in ON when ice detectors sense nacelle icing conditions.

OFF Commands the nacelle anti-ice valve to close.

Wing anti-ice switch

ON When in flight, enables the left and right wing anti-ice valves to open. The valves are electrically moved by power from AC bus 2. Green WAI flags are shown between the N1 tapes on the primary EICAS. The thrust idle-limit increases to approach-idle.

AUTO Same function as in ON when ice detectors sense wing icing conditions and when the leading edge flaps are retracted.

OFF Commands the left and right wing anti-ice valves to close.

Anti-Ice A *without Automatic Control:*

Nacelle anti-ice switch

ON Enables the respective engine‘s nacelle anti-ice valve to open. The valve requires bleed air pressure to move to the open position (during engine start, the pressure may be too low to open the valve). A green NAI flag is shown next to the associated N1 tape on the primary EICAS. The thrust idle-limit increases to approach-idle.

A *GE engines:*
Both igniters operate continuously.

A *PW engines:*
The manually or automatically selected igniters operate continuously.

A *RR engines:*
Igniters operate when an engine failure is detected (auto-relight), or when manually activated.

VALVE LIGHT Disagreement is detected between the switch position and the nacelle anti-ice valve position.

Wing anti-ice switch

ON When in flight, enables the left and right wing anti-ice valves to open. The valves are electrically moved by power from AC bus 2. Green WAI flags are shown between the N1 tapes on the primary EICAS. The thrust idle-limit increases to approach-idle.

VALVE LIGHT Disagreement is detected between the switch position and the left or right wing anti-ice valve position.

EICAS Messages:

CAUTION MESSAGES (accompanied by caution light and beeper sound)		
>ICING NAC ()		ice detector senses nacelle icing conditions AND nacelle anti-ice is deactivated AND aircraft is in flight

ADVISORY MESSAGES		
>ANTI-ICE NAC		ice detector does not sense nacelle icing conditions AND total air temperature is above 12°C AND any nacelle anti-ice is activated
>ANTI-ICE WING		ice detector does not sense wing icing conditions AND total air temperature is above 12°C AND any wing anti-ice is activated
HEAT () AOA		AOA probe (L or R) heater fault
HEAT () TAT		TAT probe (L or R) heater fault
HEAT P/S ()		pitot-static probe (CAPT or F/O) heater fault
HEAT P/S () AUX		auxiliary pitot-static probe (L or R) heater fault
HEAT WINDOW ()	INOP LIGHT	window (L or R) heat controller fault OR sensor fault OR power disconnected
>ICE DETECTORS		both ice detectors are inoperative
>ICING WING		ice detector senses wing icing conditions AND wing anti-ice is deactivated AND aircraft is in flight
NAI VALVE () A	VALVE LIGHT	nacelle (1, 2, 3, or 4) anti-ice valve position disagrees with commanded position AND engine is running
WAI VALVE () A	VALVE LIGHT	wing (L or R) anti-ice valve position disagrees with commanded position

EICAS Messages:

STATUS MESSAGES		
ANTI-ICE NAC ()	A VALVE LIGHT	engine (1, 2, 3, or 4) nacelle anti-ice valve disagrees with commanded position AND engine is running
ANTI-ICE WING ()	A VALVE LIGHT	wing (L or R) anti-ice valve disagrees with commanded position
HEAT () AOA		AOA probe (L or R) heater fault
HEAT () TAT		TAT probe (L or R) heater fault
HEAT P/S ()		pitot-static probe (CAPT or F/O) heater fault
HEAT P/S () AUX		auxiliary pitot-static probe (L or R) heater fault
ICE DETECTOR ()		ice detector (L or R) is inoperative
WINDOW HEAT ()	INOP LIGHT	windshield heat controller (1L, 1R, 2L, or 2R) failure OR sensor fault OR power disconnected

Limitations in the Simulator:

The status message NAI DUCT () LEAK is not included as such leaks are not modeled.

Landing Gear

System Overview:

Gear steering

The landing gear consists of 2 body gear, 2 wing gear, and 1 nose gear. The body gear and the nose gear are steerable. The steering mechanism is powered by hydraulic system 1. The flight deck provides a steering tiller for the captain and one for the first officer. When the tiller is fully rotated to the left or right, the nose gear is turned by 70° into the respective direction. The body gear turns out of its center position when the nose gear turn angle exceeds 20°, and when the wheel speed is below approximately 18 kt. Otherwise, the body gear is centered. It is also centered when the IRS is aligned and the IRS computed groundspeed is above circa 45 kt, or when the air-ground logic is in air mode. When the body gear turns, it turns opposite to the nose gear direction; this is because the body gear is located aft of the aircraft's center axis. Body gear steering reduces the turning radius of the aircraft.—The nose gear can also be turned by the rudder pedals up to 7° in either direction.

Wheel brakes

The pilots' brake pedals allow symmetric and asymmetric braking of the wing and body gear. There are no brakes on the nose gear. The normal brake system is powered by hydraulic system 4. If this fails, the alternate brake system activates. The alternate brake system is powered by hydraulic system 1; or, if that fails, by hydraulic system 2.—Autobrakes may be armed with a preselected, fixed groundspeed deceleration for the landing rollout; or may be armed for a rejected takeoff which will aim at maximum deceleration.—A parking brake lever can be used to lock the brake pedals in the fully depressed positions. *(In the simulator, the brakes can be promptly cooled by the **Cool brakes** button on **Instructor** > **Situation** > **Service**.)*

Antiskid

The antiskid system operates during autobrake activity as well as during manual braking. It detects skidding by comparing the wheel speeds with the IRS computed groundspeed. When skidding is detected, the brake pressure on the affected wheels is automatically reduced.

Brake torque limiters

Each wheel is fitted with a brake torque sensor. When an excessive torque is detected, the brake pressure is reduced in order to prevent structural damage.

(continued next page)

System Overview: *(continued)*

Gear retraction and extension

Hydraulic system 1 actuates the nose and body gear; hydraulic system 4 actuates the wing gear. In case of low hydraulic pressure, all gear can be extended by gravity.

Air-ground relay system

Various sensors are installed in the landing gear framework. They detect, among other things, whether the nose gear strut is compressed, whether the body and wing gear trucks are tilted, and whether the body gear is down and locked. The proximity switch electronics unit (PSEU) evaluates the sensor signals and accordingly energizes or relaxes certain relays. These relays inform a multitude of other aircraft systems—such as FMCs, autobrakes, and so on—about whether the aircraft is on the ground or in flight. In case of a power loss, some relays relax to the *ground* position, while other relays relax to the *air* position, depending on the respective worst-case option; for example, the air-ground relay that unlocks the thrust reversers will, in case of a power loss, relax to the *air* position, so that the reversers remain disabled in flight. They will then be disabled on the ground as well. But this option is safer than enabling the reversers in flight.

PNF

In the simulator, the virtual Pilot Non-Flying (PNF) may set the gear lever to the OFF position after takeoff when climb thrust is set and the gear is up, and may set the autobrakes when descending through 15000 ft. The PNF can be deactivated on **Instructor** > **Situation** > **Human** > **Pilot** by clearing the checkbox **Performs silent tasks**.

SYSTEM ANALYSIS

In the simulator, touchdown data records are indicated on **Instructor** > **Analysis** > **Touchdown**. The data is also accessible through the simulator's main network.

Simulator Specific Features:

In the simulator, the pilots' steering tillers and pedals are not displayed in their original shape. Instead, the current tiller and pedal positions are indicated in a symbolic way on a small info tag. The tag is shown in the upper left corner of the flight deck frame. It can be hidden by deselecting the checkbox **Show info tags** on **Instructor** > **Preferences** > **Basics**.

The steering tiller can be fully turned by the mouse, or by an USB axis, or by TCP/IP network inputs.

The nose gear can also be turned (to a maximum of 7°) by the rudder pedals which may be moved by the DEL, END, and Page-Down keys on the PC keyboard; or by an USB axis, or by TCP/IP network inputs.

The brake pedals (toe pedals) can be symmetrically moved by the space key on the PC keyboard; or symmetrically and asymmetrically by USB buttons, or USB axes, or TCP/IP network inputs.

For more details, refer to chapter **Simulator Handling**.

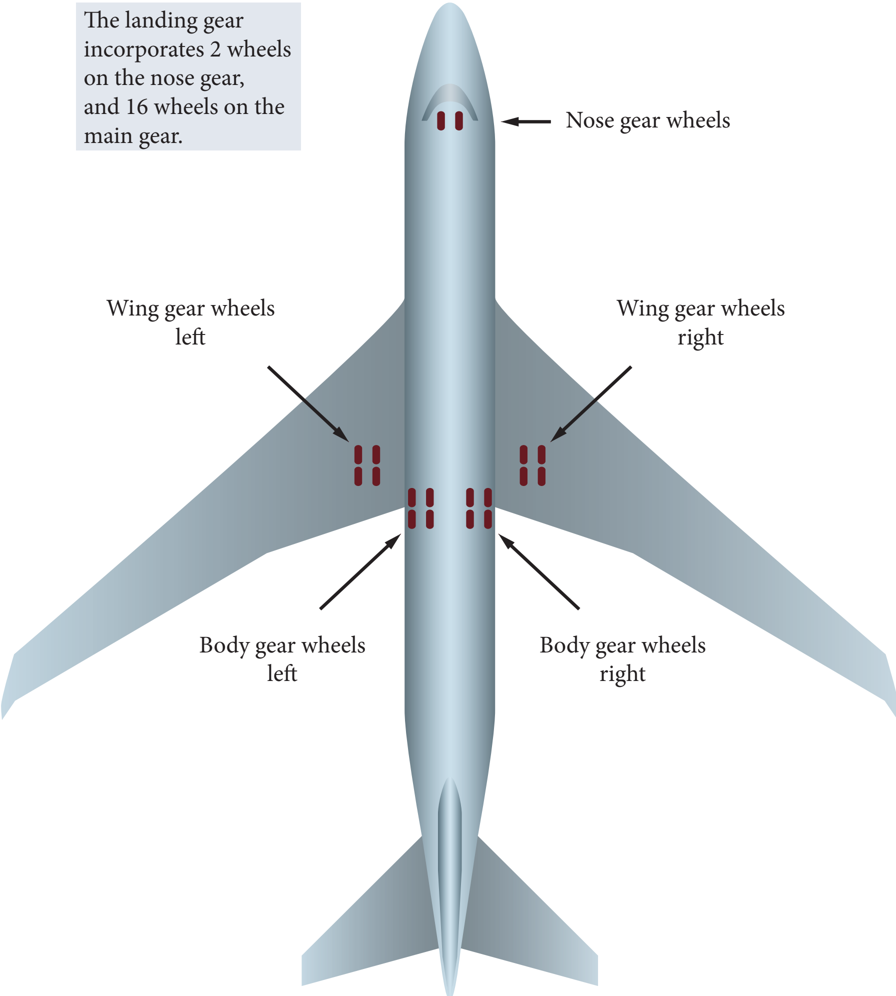
Example: The tiller (orange) is deflected to the right by circa 40°. When the tiller is centered, the orange symbol is removed.

Example: The left and right brake pedals (magenta) are pushed. The left brake pedal is almost fully forward, the right one is approximately halfway forward. When a brake pedal is fully released, the respective magenta symbol will drop to the bottom and then disappear.

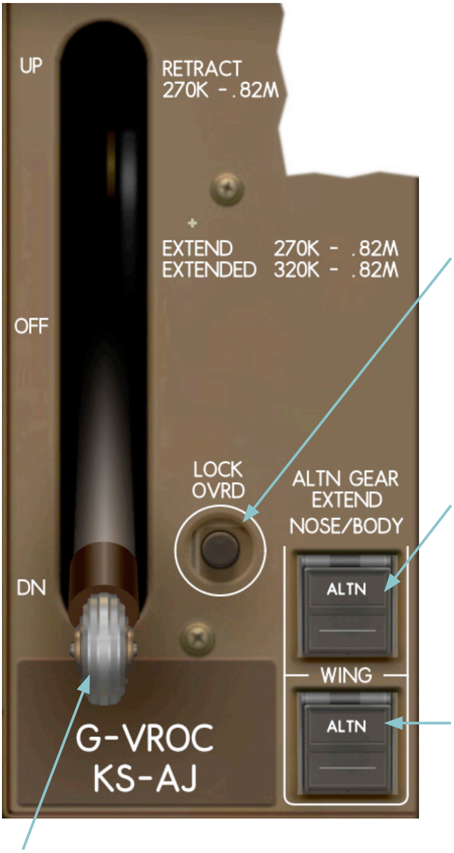
The tiller is centered, and the brake pedals are released.

Wheel Locations:

The landing gear incorporates 2 wheels on the nose gear, and 16 wheels on the main gear.



Gear Actuation:



Gear lever lock override switch
On the ground, the gear lever is locked below the UP position. When airborne, the lock is automatically removed by a solenoid, so that it is not necessary to override the lock manually.

Push (momentary action) The gear lever remains unlocked as long as the override switch is held in the pushed position. *(In the simulator, when the switch is clicked by the mouse, the switch remains pushed for 2 seconds to allow the mouse to move on and click on the gear lever.)*

Alternate nose/body gear extend switch (guarded and wired)

ALTN Releases the doors and uplocks of the nose and body gear electrically to allow extension by gravity.

Alternate wing gear extend switch (guarded and wired)

ALTN Releases the doors and uplocks of the wing gear electrically to allow extension by gravity.

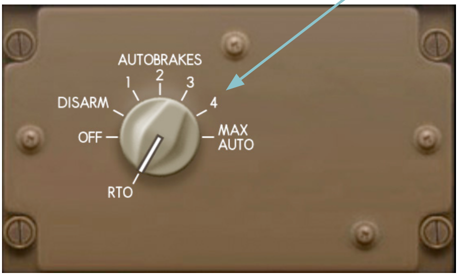
Gear lever
The lever must be pulled before moving it up or down.

UP Releases the downlocks and pressurizes the hydraulic actuators for the retraction.

OFF Depressurizes all hydraulic gear actuators.

DN Releases the uplocks and pressurizes the hydraulic actuators for the extension.

Autobrakes:



Autobrakes selector
To move the selector from OFF to DISARM or vice versa, the selector must be pushed.

RTO Arms the system for automatic rejected takeoff (RTO) braking. When the thrust lever angles of engines 2 and 4 are reset below 8° while the groundspeed is above 85 kt, the autobrakes will apply and maintain the maximum brake pressure of 3000 psi until the brake pedals are manually depressed.
The selector is spring-loaded; it automatically turns to the OFF position when airborne.

OFF Resets the logic and disconnects the power from the system.

DISARM Disarms the system and releases any automatically applied brake pressure.

1 to MAX Arms the system for automatic braking during landing rollout. Upon touchdown, the autobrakes will aim at a fixed deceleration, which is:
- 4 ft/sec^2 in position 1
- 5 ft/sec^2 in position 2
- 6 ft/sec^2 in position 3
- 7.5 ft/sec^2 in position 4
- 11 ft/sec^2 in MAX AUTO

On the ground, when the pilot depresses the brake pedals, the spring-loaded selector automatically turns to the DISARM position.

A The selector may be installed on the aisle stand or below the captain‘s ND.

The autobrake system is inoperative when hydraulic system 4 is depressurized, or when the IRS is not aligned.

Parking Brake:

Parking brake lever

Pull Locks both brake pedals in their fully depressed positions when the following procedure has been applied:

1. Fully depress both brake pedals while holding the parking brake lever in the pulled position.
2. Release both brake pedals.
3. Release the parking brake lever.

The parking brake can be released by depressing both brake pedals again while not pulling on the lever.

(In the simulator, the above procedure can be accomplished also on the PC keyboard: hold the space key and the B key simultaneously, then release the space key, then the B key. To release the parking brake, push the space key again.)

Brake Pressure Indications:

Normal brake accumulator pressure indicator
Indicates the hydraulic pressure stored in the brake accumulator, charged by hydraulic system 4. When hydraulic systems 1, 2, and 4 are depressurized, the brakes are powered solely by the remaining pressure stored in the accumulator. The initial pressure is high enough to allow the crew to set the parking brake. Multiple pedal movements should be avoided as each movement will discharge the accumulator by some psi. The normal pressure range is indicated in green, the minimum operation range in amber, and the abnormal range in red.

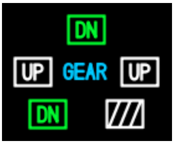
Brake source light
Illuminates when low pressure is detected in all brake relevant hydraulic systems; that is, in system 1, 2, and 4.

Primary EICAS Gear Indications:

Indicates that all gear are up and locked. Blanks after 10 seconds.

Indicates that any gear is in transit to the up or down position.

Indicates that all gear are down and locked.



Indicates the status of each gear when a system fault has occurred, or when alternate gear extension is in use.

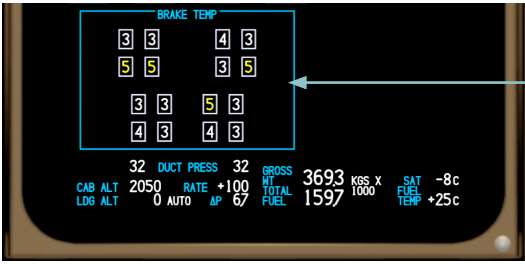
Indicates that the gear position sensor systems are inoperative.

EICAS Gear Synoptics:

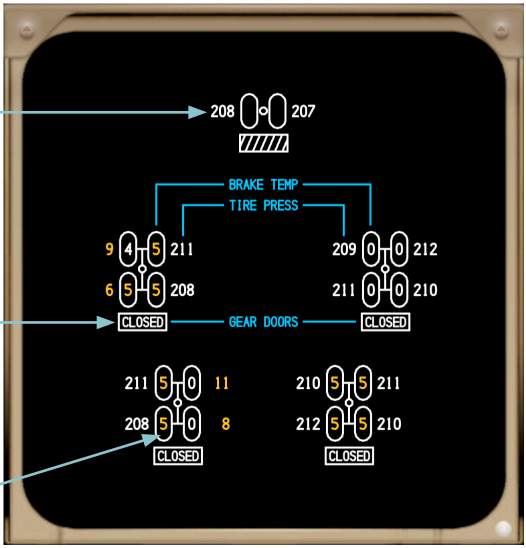
Gear synoptic switch

First push Shows gear synoptic on secondary EICAS display if display is available; otherwise shows compacted brake temperature indications on primary EICAS display.

Second push Removes gear synoptic or compacted indications from EICAS displays.



Compacted brake temperature indications



A Tire pressure in psi units (amber when in abnormal range)

Gear door status (closed or in transit)

Brake temperature.
0 to 4 (white): 100 to 482°C
5 to 9 (amber): 483 to 865°C

EICAS Messages:

CAUTION MESSAGES (accompanied by caution light and beeper sound)		
>BRAKE SOURCE	BRAKE SOURCE LIGHT	low pressure in hydraulic systems 1, 2, and 4
GEAR DISAGREE		any gear has not been in the commanded position for at least 34 seconds
>TIRE PRESSURE		abnormal pressure in one or more tires AND aircraft on ground AND thrust not in takeoff range

ADVISORY MESSAGES		
AIR/GND SYSTEM		air-ground relay system is inoperative (respective aircraft systems may erroneously be locked either in air mode or ground mode)
ANTISKID		fault detected in antiskid system *[message inhibited by ANTISKID OFF]*
ANTISKID OFF		antiskid power removed from all wheels OR parking brake valve not fully open when commanded open OR no inputs from brake system control unit
AUTOBRAKES		autobrakes are disarmed OR have failed
>BODY GEAR STRG		body gear steering system not in commanded mode
BRAKE LIMITER		two or more brake torque limiters have failed OR parking brake valve not fully open when commanded open OR no inputs from brake system control unit
BRAKE TEMP		any brake temperature in amber range
>TIRE PRESSURE		abnormal pressure in one or more tires AND { aircraft in flight OR thrust in takeoff range }

MEMO MESSAGES		
AUTOBRAKES ()		autobrakes mode (RTO, 1, 2, 3, 4, or MAX) selected
PARK BRAKE SET		parking brake is set

EICAS Messages:

STATUS MESSAGES		
ANTISKID		fault detected in antiskid system *[message inhibited by ANTISKID OFF]*
ANTISKID OFF		antiskid power removed from all wheels OR parking brake valve not fully open when commanded open OR no inputs from brake system control unit
AUTOBRAKES		autobrakes are disarmed OR have failed
BODY GEAR STRG SYS		body gear steering system not in commanded mode
BRAKE LIMITER		two or more brake torque limiters have failed OR parking brake valve not fully open when commanded open OR no inputs from brake system control unit
BRAKE TEMP SYS		brake temperature monitoring system has failed OR no inputs
GEAR DISAGREE		any gear has not been in the commanded position for at least 40 seconds
PARK BRK VALVE		parking brake valve not in commanded position
A TIRE PRESSURE		abnormal pressure in one or more tires

Limitations in the Simulator:

The following messages are not included as the respective malfunctions are not modeled: GEAR DOOR, GEAR MONITOR, GEAR TILT, A/G DISAGREE, NOSE AG DISAGREE, PEDAL STEERING.

Navigation Systems

For flight deck indications, refer to chapter **Flight Instruments**.

For tuning controls, refer to **NAV RADIO** in chapter **FMS**.

For station identifier audio monitoring, refer to chapter **Communications**.

System Overview:

The navigational equipment on the aircraft consists of:

3 inertial reference units (IRUs)

3 standby navigation systems, integrated in CDUs (refer to chapter **FMS**)

2 weather radar (WXR) transceivers

2 air-traffic-control transponders

3 radio altimeter (RA) transceivers

2 distance measuring equipment (DME) interrogators

2 automatic direction finder (ADF) receivers

2 very-high-frequency omnidirectional range (VOR) receivers

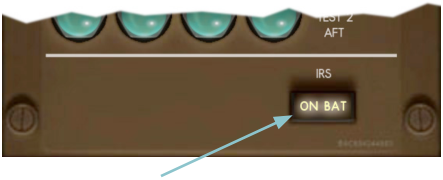
1 marker beacon receiver (provided by the left VOR receiver)

3 instrument landing system (ILS) receivers

3 microwave landing system (MLS) receivers

2 global-positioning-system sensor units (GPSSUs)

Inertial Reference System:



IRS on battery light
Illuminates after a delay of 10 seconds when any IRU is powered by the main or APU hot battery bus. (Each IRU is normally powered by a 115 V AC bus; the batteries are just used for backup power.)

IRS mode selector (IRU L, IRU C, IRU R)
To move the selector to NAV, or away from NAV, the selector must be pulled.

OFF Removes power from the IRU, and IRU loses alignment.

ALIGN If currently in ATT mode, the IRU remains in ATT mode. Otherwise, removes any existing sensor errors, and—when the aircraft is parked—performs the position alignment: this takes 30 seconds if the IRU was in NAV mode before, else at least 10 minutes and will not stop before the selector is set to the NAV position.

NAV If currently in ATT mode, the IRU remains in ATT mode. Otherwise, performs a 10-minute position alignment if not already done and if the aircraft is parked. When aligned, and when an IRS position is entered in the FMC*, the IRU will operate in NAV mode and provide attitude and navigational data to other aircraft systems.

ATT When the selector has been in the ATT position for more than 2 seconds, the IRU stops providing navigational data, loses its position alignment, and performs the attitude alignment for 10 seconds—or for 30 seconds if the IRU was off. Thereafter, the IRU will provide attitude and vertical speed only, and the magnetic heading must be initialized (and updated circa every 5 minutes) by manual entries in the FMC*.

* *Refer to* ***POS INIT*** *in chapter* ***FMS****.*

Inertial Reference System:

In **ATT** mode, the IRU provides the following data:

Pitch angle
Roll angle
Pitch rate
Roll rate
Body pitch rate
Body roll rate
Body yaw rate
Body longitudinal acceleration
Body lateral acceleration
Body normal acceleration
Vertical acceleration
Inertial vertical speed *(requires pressure altitude input from ADC)*
Inertial altitude *(requires pressure altitude input from ADC)*
Platform heading *(requires pilot inputs)*

In **NAV** mode, the IRU provides the same data as in ATT mode, plus:

Magnetic* and true heading
Magnetic* and true track *(valid when groundspeed is above 80 kt)*
Track rate
Drift angle
Flight path angle *(valid when groundspeed is above 80 kt)*
Flight path acceleration
Along track horizontal acceleration
Cross track horizontal acceleration
East-west velocity
North-south velocity
Groundspeed
Present latitude-longitude position
Wind direction and wind speed *(requires TAS input from ADC)*

* *Each IRU uses the computed present position and a global database to determine the local magnetic variation.*

Inertial Reference System:

The inertial reference system (IRS) comprises three inertial reference units—labeled as IRU L, IRU C, IRU R—, and a control module on the overhead panel containing three mode selectors.

Normally, IRU L is powered by AC bus 3, IRU C by AC bus 1, and IRU R by AC bus 2. When AC power fails, the respective IRU is supplied by the APU hot battery bus or—during APU start—by the main hot battery bus. To conserve battery power, IRU C will operate on battery power just for 5 minutes; thereafter, power is automatically disconnected from IRU C.

Each IRU incorporates ring-laser gyros to sense rotational motion, accelerometers to sense linear motion, and electronics that process the sensed data: for example, based on the sensed motion directions and velocities, the IRU continuously computes the present position. Minor errors accumulate during the flight, but they typically remain within a small, allowable tolerance.

Normal operation is only possible if a position alignment has been performed (NAV mode) and if a correct initial position has been set. The position alignment begins when the crew turns the mode selectors from OFF to NAV. The aircraft must be stationary until the alignment is completed. This will take 10 minutes. During this time, the system will sense the earth's rotation, and accordingly determine the aircraft's present true heading and latitude. In polar regions, the tangential speed of the earth's rotation is lower, causing less accurate sensor inputs; therefore, a special high-latitude alignment is necessary if the aircraft is parked north of 70°N or south of 70°S. In this case, the crew sets the mode selectors from OFF to ALIGN, leaving them there for 17 minutes, then from ALIGN to NAV.

The FMC provides controls for IRU initialization and testing. During the alignment, the IRU cannot detect the present longitude. The crew adds this data by entering the present position on the FMC POS INIT page. The system will test the entry and apply the following functions:

- If the distance between the entered position and the origin airport of the active FMC route is greater than 20 nm, the FMC message IRS POS/ORIGIN DISAGREE appears.
- If the latitude or the longitude of the entered position disagrees with that of the last stored FMC position by more than 1°, the FMC message ENTER IRS POS appears.
- If the sine of the entered latitude disagrees with that of the sensed latitude by more than 0.15, the FMC message ENTER IRS POS appears.
- If the cosine of the entered latitude disagrees with that of the sensed latitude by more than 0.012, the FMC message ENTER IRS POS appears.

(continued next page)

Inertial Reference System: *(continued)*

Should an IRU, in NAV mode, lose its alignment during taxi or in flight, it can only be re-aligned for the NAV mode when the aircraft is parked. An *attitude* alignment, however, may be performed also in flight (ATT mode), but in that mode the IRU will not provide navigational data; this means, AFDS, FMS, standby navigation systems in the CDUs, ND track-up compass roses, and other functions, will be disabled. The ATT mode will also disable groundspeed dependent systems like autobrakes and antiskid.—During an *attitude* alignment, the aircraft should be level and maintain a constant airspeed. The alignment resets the pitch and bank angles to zero, regardless of the current aircraft attitude. Thereafter, long-term gravity sensing will gradually add the true vertical reference, so that, after a period of several minutes, the correct aircraft attitude will be sensed. In ATT mode, the IRU provides neither true nor magnetic heading. Instead, it provides the heading the crew enters. The IRU just adds rotational motion to the entered heading. The crew should enter *magnetic* headings, so that the VOR pointers on the compass roses accurately indicate VOR radials with reference to magnetic north as published. Also, when the heading reference switch is set to TRUE while in ATT mode, the RMI and EFIS compass roses will be inoperative.

The crew may apply a fast 30-second alignment for the NAV mode when there is not enough time for a 10-minute alignment. This requires the IRU being aligned already (after a flight, for example) and showing no excessive position errors: when the aircraft is parked, the crew sets the mode selectors from NAV to ALIGN, and back to NAV. This fast alignment does not require a position entry in the FMC; the entry is recommended though.

In the simulator, the IRS alignment time can be reduced with the **Time acceleration** slider on **Instructor** > **Situation** > **Time**. The IRS can also be aligned promptly by pushing the button **Align IRS & standby gyro** on **Instructor** > **Situation** > **Service**. This works on the ground as well as in flight, and has the effect of a 17-minute alignment. However, it will align just those IRUs that are set to NAV. Once an IRU is in ATT mode, it will remain in ATT mode until it is reset to OFF. Therefore, to assure an IRU is actually set to NAV, first move the IRU mode selector to OFF, then to NAV, then push the button on the Instructor.

SYSTEM ANALYSIS

In the simulator, sine and cosine test results for each IRU are shown on **Instructor** > **Analysis** > **Navigation** under **IRS latitude sine/cosine test**. Failed tests are marked in red.

Weather Radar System:

(There are various models of weather radar systems and panels. In the simulator, all aircraft are fitted with the system and panel discussed in this chapter.)

Captain's tilt and gain selectors

TILT Effective in manual mode only. Sets the antenna tilt angle with reference to the earth's horizon (gyro stabilized), or with reference to the aircraft attitude when the gyro system has failed. The tilt angle is indicated on the ND in cyan font.

GAIN Sets the radar sensitivity. 10 steps are available. When set to 12 o'clock position, the gain is calibrated for standard reflectivity levels, and the gain value on the ND (cyan) is blank. Otherwise: gain values are displayed in the format MIN, -G6, ... +G4, MAX, when in manual mode; VAR (variable) is shown when in automatic mode.

Captain's operation mode switches

Only one of the TFR, WX, WX+T, and MAP switches can be pushed at a time. The GC switch is independent of this.

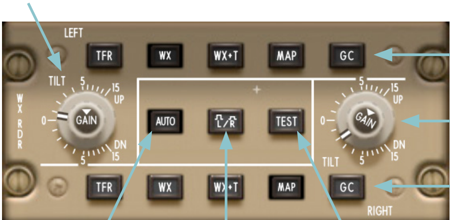
TFR Transfers the first officer's mode, gain, and tilt settings to the captain's radar (vice versa when the first officer's TFR switch is pushed instead). When both TFR switches are pushed, the test mode activates.

WX Activates the weather mode without turbulence indication. The ND shows radar return intensities in green, amber and red.

WX+T Same as WX, and the ND also indicates turbulence (in magenta) when the ND range is set below 80 nm.

MAP Effective in automatic mode only. Inhibits the ground clutter suppression and decreases the gain sensitivity to optimize the display to show coastlines and mountains rather than weather returns.

GC (momentary action) Effective in automatic mode only. Inhibits the ground clutter suppression as long as the GC switch is held.



First officer's controls

Identical to captain's controls, but with reference to the first officer's ND.

Automatic mode switch

Push Activates the automatic mode. For details, refer to the next page.

Transceiver switch

Push Activates the right transceiver, else the left one.

Test switch

Push Tests the system. Both NDs will show a test raster, and predictive windshear alerts will sound.

Weather Radar System:

(The simulator models one type of radar system on all aircraft: it is a simplified simulation of the Collins WXR-2100 MultiScan™ radar.)

A weather radar antenna is installed in the nose section of the aircraft. The antenna attitude is stabilized with reference to the horizon by data inputs from the IRS. The radar system includes two weather radar transmitter-receivers (transceivers) labeled as left and right transceivers (L and R). One transceiver operates at a time, and provides signals for both pilots' instruments. The other transceiver is used as a backup.

When automatic control is selected, the system varies the antenna tilt angle, scans ground clutter ("look down") and weather ("look up"), and applies digital signal processing to distinguish the ground clutter returns from weather returns when the tilt angle is normal. When the radar is not in map mode, the system will remove the detected ground clutter from the raster image. The elimination process is completed after five antenna sweeps. Thereafter, when the pilot reselects the manual control, the system will keep the clutter-free image in memory for 38 seconds. When returning to automatic control within this time limit, the clutter-free image will immediately reappear, otherwise it will again take five sweeps until all detected clutter is removed.

The system also features, among other things, path attenuation compensation (PAC) alerting: when a radar shadow appears behind intensive weather returns, the shadow sector will be marked on the ND compass rose by an amber arc. The PAC alert is enabled when the GAIN selector is in the calibrated setting (12 o'clock position), and the radar map mode is deselected, and the ND range is at or below 80 nm.

Windshear detection is provided in areas where precipitation is present. The system requires weather returns to measure the movement of air masses. Windshear sectors are shown on the ND by red stripe patterns and amber radials. For windshear warning systems refer to chapter **Warning Systems**.

When in automatic control, the system continuously stores radar images scanned at various range and tilt settings in memory; the images are digitally processed and optimized for all flight phases and for each pilot's ND range setting. Both pilots' radar displays will sweep left and right at the same time without pauses.—When in manual control, and when WXR is selected on both NDs, the captain's display is updated during right-turn sweeps, and the first officer's display during left-turn sweeps.

When the IRS is aligned, the radar image on the ND moves and turns with the aircraft. Otherwise, it is fixed in the look-ahead position.

ATC Transponder System:

(There are various models of transponder control panels. In the simulator, the model shown below is installed on all aircraft.)

Transponder code switch

Push Sets new transponder code. First push clears display and enters first digit. When 4-digit entry is not completed within 3 seconds, new entry is canceled and previous code reappears. Otherwise, new code becomes active when fourth digit is entered. CLR key clears display.

Altitude reporting switch

OFF or ON Turns altitude reporting off or on.

Ident switch

Push Starts ident signal transmission. Automatically stops after 20 seconds.

Transponder code display

Indicates selected transponder (ATC L or R) and entered code.

Flight level switch

Push Starts TCAS flight level display mode: altitude labels on TCAS targets on ND refer to absolute instead of relative altitudes. After 15 seconds, display automatically returns to normal mode.

Transponder selector

L or R Enables the left or right transponder to operate when in flight.

Above-below selector

Enables ND to show TCAS targets whose relative altitudes are between:

A +7000 and -2700 ft.

N +2700 and -2700 ft.

B +2700 and -7000 ft.

Transponder fail light

Indicates transponder fault.

Control selector

STBY Deactivates transponders.

XPDR Activates selected transponder.

TA Same as XPDR, and enables TCAS TA alerts.

RA/TA Same as XPDR, and enables TCAS RA and TA alerts.

ATC Transponder System:

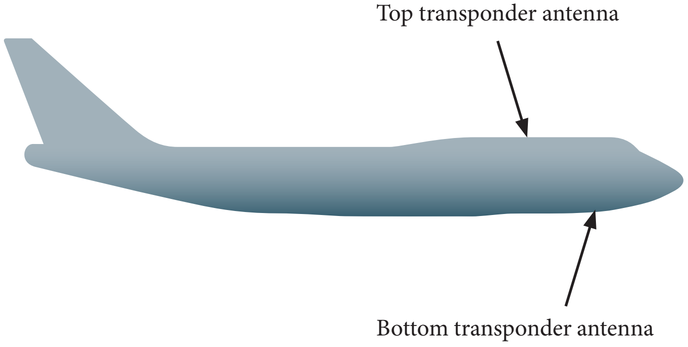
For TCAS warnings, refer to chapter **Flight Instruments** and chapter **Warning Systems**.

The ATC system includes two antennas, two transponders, and a single ATC control panel. Pressure altitude data for the altitude reporting function is provided by the ADCs. The air-ground status is set by air-ground relays: the transponders are automatically deactivated when the aircraft is on the ground.

SYSTEM ANALYSIS

In the simulator, the physical transponder status is indicated on **Instructor** > **Analysis** > **Navigation** by a 6-digit string. The 1st digit indicates the mode (1=off, 2=on, 3=on with altitude reporting), the 2nd digit indicates the ident function (0=ident off), and the last four digits indicate the active code. The string is also accessible through the simulator's main network.

Antenna locations

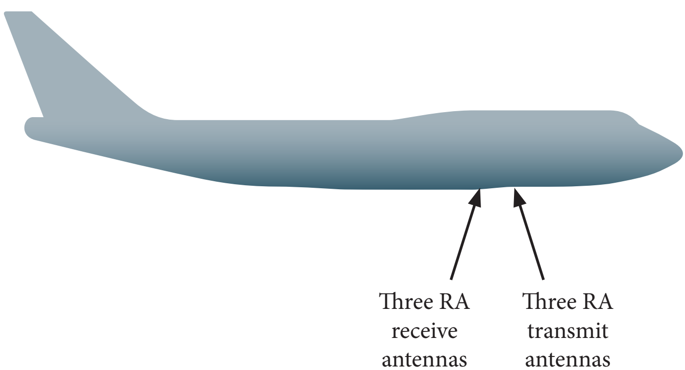


Radio Altimeter System:

The aircraft is fitted with a low-range radio altimeter system which measures the obstacle clearance altitude, also called radio altitude (RA). The system is designed for low altitude operation up to 2500 ft RA. The altitude data is sent to the EFIS, to various alerting systems, and to the flight control computers. The radio altimeter system comprises three independent units; each unit includes a transmit antenna and a receive antenna. The system is calibrated so that during landing the following RA values are indicated:

- When the aircraft pitch attitude is circa 3°, and the lower wheels on the tilted main gear trucks touch the ground, the RA indication reads 0 ft. At this point, the aircraft systems are still in air mode.
- When the gear trucks are no longer tilted, that is, when all main wheels are on the ground, the RA indication is in the range of -2 to -4 ft. At this point, the aircraft systems change to ground mode.
- When the nose gear is on the ground and all gear struts are compressed, the RA indication is in the range of -6 to -8 ft, depending on the aircraft weight and balance.

Antenna locations



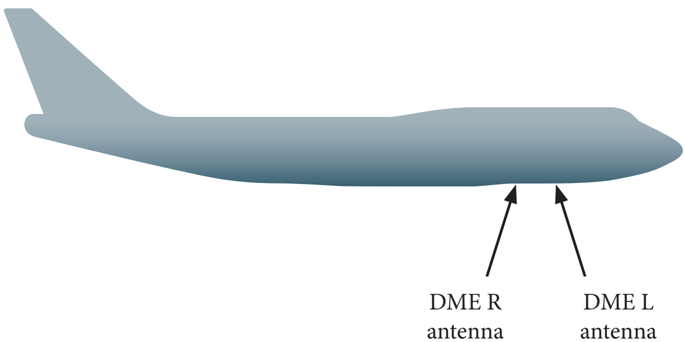
DME System:

Two DME interrogators and antennas are installed, labeled as DME L and DME R. The DME measures the line-of-sight (slant range) distance between the aircraft and a tuned ground station. The FMC uses DME data for aircraft position updating; it calculates the unslanted ground distance by taking the station elevation from the navigation database and the current aircraft altitude into account. Each DME scans distance signals from multiple stations by using five independent channels:

- Channels 1 & 2 are used and autotuned by the FMC for position updating.
- Channels 3 & 4 are used for procedure, route, and manual tuning.
- Channel 5 is used for the tuned ILS-DME station.

(The simulator models the station elevation of each DME, and the power class specific and figure-of-merit specific service range of each DME station.)

Antenna locations

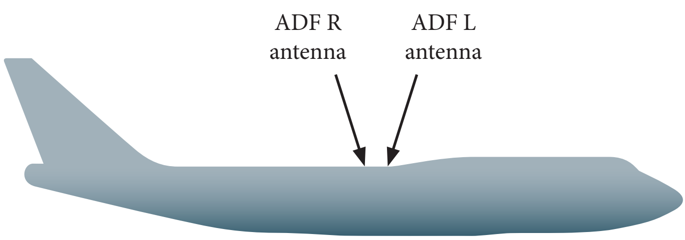


ADF System:

Two ADF systems are installed, labeled as ADF L and ADF R. Each system includes a sense and loop antenna unit, and a receiver which can operate in beat frequency oscillation (BFO) mode and in normal mode. For broadcast audio monitoring, the loop antenna can be disabled by setting the desired system to *antenna* mode (refer to **NAV RADIO** in chapter **FMS**); when this mode is set, the respective ADF pointer will be removed from the NDs, and—if an RMI is installed—the respective ADF pointer on the RMI will park in 9 o'clock position. For Morse identifier audio monitoring, the system may be left in normal navigation mode.

(The simulator models typical ADF effects, such as the thunderstorm effect, night effect, attitude dip error, and signal bending by aircraft surfaces. It also models the power class specific service range of each NDB.)

Antenna locations

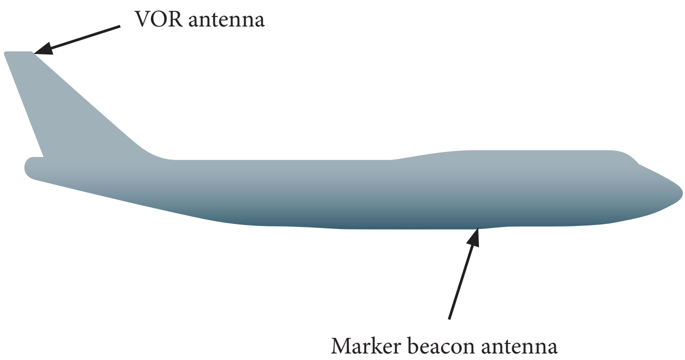


VOR and Marker Beacon Systems:

Two VOR systems are installed on the aircraft, labeled as VOR L and VOR R. Both systems use one common VOR antenna (the VOR antenna is also used by the localizer receivers until the localizer beam is captured for the approach). Each VOR system integrates a marker beacon receiver, but the marker beacon receiver in VOR R is permanently disabled. The marker beacon antenna receives signals when the aircraft is overflying an outer marker (OM), middle marker (MM), or inner marker (IM)—or an airway marker; airway markers are indicated by IM symbols, but use specific Morse identifiers that are different to the standard IM Morse identifier.

(The simulator models the VOR cone-of-confusion effect, and the power class specific and figure-of-merit specific service range of each VOR.)

Antenna locations



ILS, MLS, GPS:

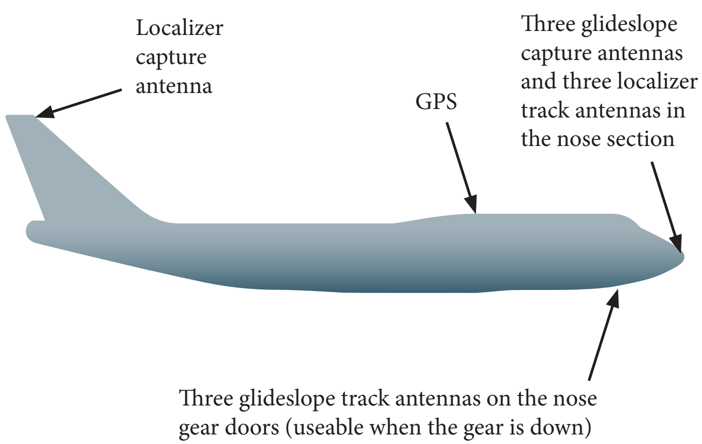
The aircraft is equipped with three multimode receivers (MMRs), labeled as MMR L, MMR C, MMR R. They integrate two GPS sensor units, and three ILS and MLS receivers:

- MMR L integrates ILS L, MLS L, and GPS L.
- MMR C integrates ILS C and MLS C.
- MMR R integrates ILS R, MLS R, and GPS R.

The ILS antenna system is also used by the MLS receivers. It consists of one localizer *capture* antenna (which is also used by the VOR receivers), three localizer *track* antennas (used when the localizer is captured for the approach), three glideslope *capture* antennas (used when the gear is up), and three glideslope *track* antennas (used when the gear is down).

(The simulator models, among other things, the satellite acquiring time of the GPS, and can model ILS antenna system misconfigurations, radio interference, and glideslope antenna switch effects.)

Antenna locations



EICAS Messages:

CAUTION MESSAGES (accompanied by caution light and beeper sound)		
ILS ANTENNA		{ gear is down AND more than one glideslope system not switched from capture antenna to track antenna } OR { flight control computer has captured localizer AND more than one localizer system not switched from capture antenna to track antenna }

ADVISORY MESSAGES		
>GPS		fault in both GPS sensor units
>GPS ()		fault in one GPS sensor unit (LEFT or RIGHT)
IRS ()		fault in IRU (LEFT, CENTER, or RIGHT)
>IRS AC ()		AC power loss in IRU (LEFT, CENTER, or RIGHT)
>IRS DC ()		DC power loss in IRU (LEFT, CENTER, or RIGHT)
IRS MOTION		aircraft motion detected during position alignment
TRANSPONDER ()		fault in transponder (L or R)

MEMO MESSAGES		
IRS ALIGN MODE ()		IRU (L, C, or R) alignment in progress

EICAS Messages:

STATUS MESSAGES		
ADF ()		ADF (L or R) failure
ATC ()		transponder (LEFT or RIGHT) failure
DME ()		DME (L or R) failure
G/S ANTENNA ()		{ gear is down AND glideslope system (L, C, or R) not switched from capture antenna to track antenna } OR { gear is up AND glideslope system (L, C, or R) not switched from track antenna to capture antenna }
ILS ()		ILS (LEFT, CENTER, or RIGHT) failure
IRS ()		fault in IRU (LEFT, CENTER, or RIGHT)
IRS AC ()		AC power loss in IRU (LEFT, CENTER, or RIGHT)
IRS DC ()		DC power loss in IRU (LEFT, CENTER, or RIGHT)
LOC ANTENNA ()		{ flight control computer has not captured localizer AND localizer system (L, C, or R) not switched from track antenna to capture antenna } OR { flight control computer has captured localizer AND localizer system (L, C, or R) not switched from capture antenna to track antenna }
RADIO ALT ()		radio altimeter (LEFT, CENTER, or RIGHT) failure
VOR ()		VOR (L or R) failure

Power Plant

System Overview:

The aircraft is fitted with four engines—sometimes referred to as power plants. Each engine can provide forward and reverse thrust, and includes components that generate bleed air, electrical power, and hydraulic power to drive various systems onboard the aircraft (refer to chapters **Air Systems**, **Electrical**, and **Hydraulics**). The engine thrust is controllable manually and automatically (refer to chapter **Automatic Flight**); and the electronic engine control (EEC) maintains rotor speeds and other parameters within the allowable limits.—Some aircraft are equipped with engine autostart systems.

Either General Electric (GE), Pratt & Whitney (PW), or Rolls-Royce (RR) engines are installed on the aircraft. The exact model depends on the aircraft variant:

For extended-range (ER) aircraft, the engine models available are:

- CF6-80C2B5F (GE)
- PW4062 (PW)
- RB211-524H8 (RR)

For non-ER aircraft:

- CF6-80C2B1F (GE)
- PW4056 (PW)
- RB211-524G (RR)

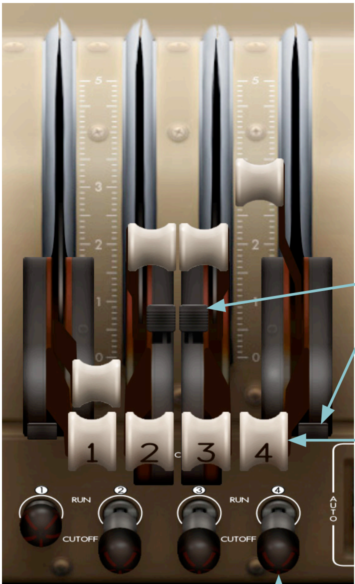
The major differences between the engine models being:

- Engine strut size: affects maximum available wing tank fuel volume
- Fire and overheat protection (refer to chapter **Fire Protection**)
- Thrust reverser mechanism: hydraulically or pneumatically driven
- Turbine design: two-rotor or three-rotor system
- Thrust measuring method: integrated EPR, core EPR, no EPR
- Specific operation limits re EGT, oil, N1, N2, and other parameters
- Electronic engine control specification
- Ignition system logic
- Engine bleed air system design
- Hydraulic EDP pressure minimum for automatic demand pump start
- EICAS symbology

SYSTEM ANALYSIS

In the simulator, the status of bleed air valves (PRSOVs), start valves, fuel shutoff valves (SOVs), fuel valves, ignition exciters, and fuel control switch run time (seconds) are indicated on **Instructor** > **Analysis** > **Miscellaneous**. O=open; R=Reversed; c=closed; 1=igniter 1; 2=igniter 2; B=both igniters. The data strings are also accessible through the simulator's main network.

Forward Thrust Levers and Fuel Control Switches:



*(In the simulator, the thrust levers can be moved by mouse, keyboard, USB, and TCP/IP network inputs. Refer to chapter **Simulator Handling**.)*

TO/GA and A/T disconnect switches: refer to **Autothrottle Controls** in chapter **Automatic Flight**.

Forward thrust lever (engines 1, 2, 3, 4)
In this example, all four forward thrust levers are set to idle.

Fuel control switch (engines 1, 2, 3, 4)
The switch must be pulled before changing from RUN to CUTOFF or back.

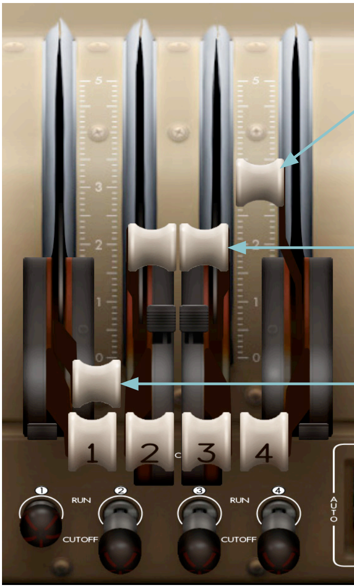
RUN Opens the fuel spar valve in the airframe and the engine fuel valve in the nacelle.

For engine start with *autostart installed and enabled*: arms the autostart sequence; the start valve, the fuel metering valve, and the igniters will be controlled automatically.

For engine start with *autostart off*: energizes the igniters.

CUTOFF Closes the fuel spar valve and the engine fuel valve, disconnects the igniters from their power supplies, unlocks the associated engine fire switch, and—if the respective demand pump selector is set to AUTO—commands the hydraulic demand pump to run.

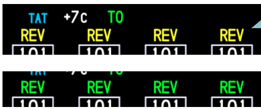
Reverse Thrust Levers:



Reverse thrust lever engine 4
In this example, pushed down; that is, the reverser is commanded to retract to the stowed position.

Reverse thrust levers engines 2 & 3
In this example, set to reverse idle; that is, the reversers on engines 2 and 3 are commanded to deploy when the aircraft is on the ground. Pulling a lever to this position is possible when the associated *forward* thrust lever is at idle.

Reverse thrust lever engine 1
In this example, set to maximum reverse thrust. The lever can be moved into the higher-than-idle range when the reverser is sufficiently deployed.



EICAS REV flag (amber when reverser is in transit, green when fully deployed).

After touchdown, or when rejecting a takeoff, proceed as follows:

1. Pull the reverse thrust levers to the reverse idle position. This commands the reversers on the engine nacelles to deploy. The deployment takes circa 2 seconds, during which the EICAS will show amber REV flags.
2. When the reversers are sufficiently deployed, the REV flags turn green, and the internal lever lock opens, allowing the crew to apply reverse thrust: pull the reverse thrust levers to the desired thrust setting.
3. When decelerating through 80 kt, push the reverse thrust levers to the reverse idle position and wait until the engines have spooled down to idle, which typically occurs when passing 60 kt (stowing the reversers *before* the thrust has reached idle, will momentarily generate forward thrust).
4. Push the levers fully down; the REV flags turn amber as the reversers transit to the stowed position. When stowed, the REV flags disappear.

After touchdown, the autobrakes will modulate the wheel brake pressure for a constant groundspeed deceleration; therefore, reverse thrust will not increase the deceleration, but it will relieve the brakes. Further, most of the reverse thrust exhausts *sideways*; the compressed air in the engine mainly provides aerodynamic *drag*. The lower the airspeed, the lower the drag: at taxi speeds, the drag provided by reverse thrust is nearly zero (the system is designed for speeds above 80 kt).

Electronic Engine Control:

General

The EEC monitors signals from various sensors, processes the data, and commands actuators for operational and protective adjustments. Under normal conditions, the EEC has full authority over the operation of the engine.

Power supply

The EEC is primarily powered by a dedicated alternator, driven by the N2 (or N3) rotor through the engine accessory gearbox. On GE and PW models the alternator supplies sufficient power when the N2 RPM is above 10%;—on RR models when the N3 RPM is above 8%. When the rotor speed is too low, the EEC may be powered by a related DC bus: EEC 1 by DC bus 1, EEC 2 by DC bus 2, and so on. The EEC will operate on DC power after a delay of 4 to 16 seconds when any of the following conditions is true:

- Start switch is pulled
- Fuel control switch is set to RUN
- EEC maintenance switch is set to TEST

Some of the EICAS engine indications are supplied by the EEC; the following indications are blank when the EEC is not powered:

+ EPR on PW & RR models
+ EGT
+ Oil temperature
+ Fuel flow on GE models

EEC modes

The EEC operates either in normal mode or in alternate mode. On GE models, the thrust controlling parameter is always N1. On the other models, EPR is the controlling parameter when in normal mode, and N1 when in alternate mode. In order to stabilize the commanded thrust, the EEC modulates the fuel flow. To determine the commanded thrust, the EEC basically uses three variables: the maximum allowable N1 speed under the current conditions, the idle thrust limit under the current conditions, and the sensed thrust lever angle (TLA). The maximum TLA commands the current maximum limit, the minimum TLA commands the current idle limit, and the TLAs in between command the respective thrust ratios. This means, when the current conditions (air data, anti-ice, flight phase) change, the commanded thrust will vary as well—while the TLA remains constant (the EEC is not an autothrottle). On GE models, when in alternate mode, the maximum allowable N1 RPM (amber line) may be exceeded: it may be exceeded even when the TLA is *below* the maximum. Hence, before switching from normal to alternate mode, the crew should assure the thrust levers are positioned below the critical range.

(continued next page)

Electronic Engine Control: *(continued)*

Thrust equalization

After takeoff, the EECs will trim the fuel flow so that all four thrust settings are equal, provided the differences do not exceed the allowable trim range. The allowable trim range depends on the current pressure altitude and varies between 1.6 and 2.6% N1 on GE models, respectively 0.03 and 0.05 EPR on the other models. Of all four thrust levers, the second highest TLA sets the target thrust. The other three engines will be trimmed to this target thrust by electronic fuel flow control (the EEC will not move the thrust levers). The system is initially neutral during takeoff when the aircraft accelerates through 65 kt and when it has not yet climbed 400 ft above the ground. Thereafter, trimming is enabled when all of the following conditions are true:

On GE models:

+ Autoflight warning system is powered and FMC master is set to L; or right autothrottle servo is operative and FMC master is set to R
+ A/T switch is set to ARM
+ At least one EIU is operative
+ IAS is greater than 50 kt or autothrottle is engaged

On PW & RR models:

+ Any FMC is operative
+ A/T switch is set to ARM
+ At least one EIU is operative
+ IAS is greater than 50 kt or autothrottle is engaged

*(In the simulator, a feature called **thrust lever humanizer** may be enabled on **Instructor** > **Preferences** > **Basics**. This feature simulates the effect which occurs when all four thrust levers are moved by a human hand. That is, whenever all four levers are being moved simultaneously—by mouse, keyboard, or USB inputs—the levers will be faintly misaligned at random. This effect also demonstrates the trim function of the EEC: while the thrust lever angles slightly disagree, the actual thrust settings will be equalized by the EECs.)*

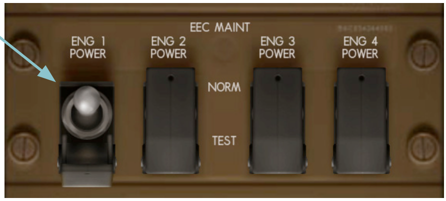
Electronic Engine Control:

A The NORM function may be in the upper or lower position.

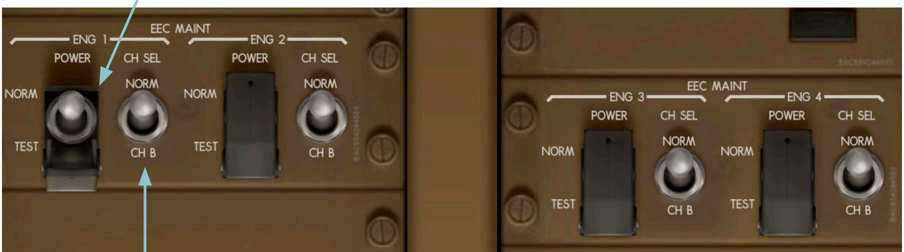
EEC maintenance power switch (guarded)

NORM Power to the EEC is selected by normal system logic.

TEST The EEC is directly connected to the associated DC bus.



A **GE & PW models**



A **RR models**

EEC maintenance channel select switch

NORM EEC controlling channel A or B is selected by system logic.

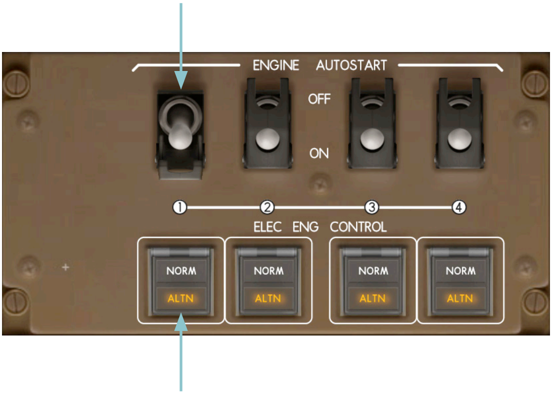
CH B EEC controlling channel B is selected for testing.

Electronic Engine Control:

A **Engine autostart switch (engines 1, 2, 3, 4)**

OFF Disables the autostart system on the associated engine. The fuel control switch must *not* be set to RUN before the N2 (or N3) RPM is spooled up to the fuel-on minimum.

ON Enables the autostart system on the associated engine. The fuel control switch must be set to RUN to initiate the autostart program.



EEC switch (engines 1, 2, 3, 4)

NORM Enables the EEC to operate in normal mode. On PW & RR models, EPR is used as the controlling parameter.

ALTN Commands the EEC to operate in alternate mode. N1 is used as the controlling parameter.

ALTN LIGHT EEC operates in alternate mode.

A

On GE models, autothrottle operation is possible when all four EECs are in the *same* mode.

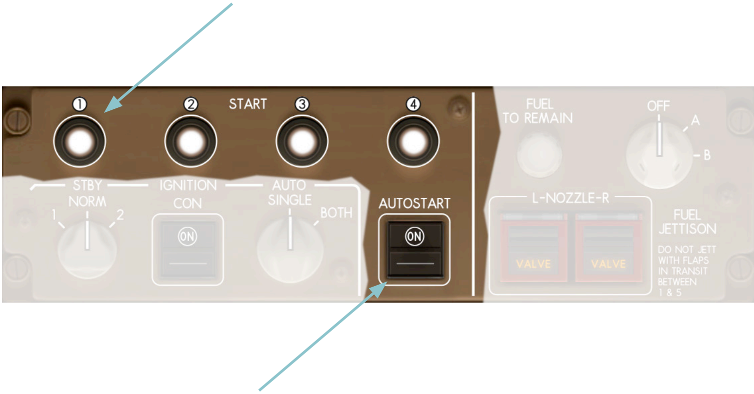
On PW & RR models, autothrottle operation is possible when all four EECs are in *normal* mode.

Engine Start Control:

Engine start switch (engines 1, 2, 3, 4)
On the ground, or inflight at low airspeeds, the N2 (or N3) rotor may be spooled up by a pneumatically driven starter motor; bleed air is directed to the starter motor through the engine bleed air valve and the start valve.

Pull If autostart is installed and on: arms the start valve and bleed air valve. If autostart is off: opens the start valve and bleed air valve immediately. In either case, when the N2 (or N3) RPM rises to 50%, the start switch automatically returns to the in-position, and the start valve and bleed air valve close.

WHITE LIGHT Start valve is open.



A **Engine autostart switch**

OFF Disables the autostart system on all engines. The respective fuel control switch must *not* be set to RUN before the N2 (or N3) RPM is spooled up to the fuel-on minimum.

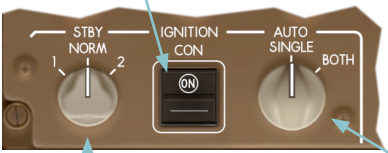
ON Enables the autostart system on all engines. The respective fuel control switch must be set to RUN to initiate the autostart program.

SYSTEM ANALYSIS In the simulator, the engine model specific autostart program phases are indicated on **Instructor** > **Analysis** > **Miscellaneous**.

Ignition Control – A GE Model:

Continuous ignition switch

ON *Continuous* ignition operates.
A Sets approach idle limit.



Each engine is equipped with a pair of igniters, labeled as igniter 1 and igniter 2.

The ignition control on the overhead panel controls each engine's igniter pair.

Normally, on each engine, igniter 1 is powered by AC bus 1, and igniter 2 by AC bus 3.

Standby power to all igniters is provided by the main standby bus which uses the main battery as a backup.

Standby ignition selector (GE)

1 Ignition operates, even if auto and continuous ignition are off. The system will energize both igniters by standby power if available; otherwise, normal power will energize igniter 2.

NORM Ignition operates when normal power to igniter 1 or 2 is lost; in this case, standby power will energize both igniters, even if auto and continuous ignition are off.

2 Ignition operates, even if auto and continuous ignition are off. The system will energize both igniters by standby power if available; otherwise, normal power will energize igniter 1.

Auto ignition selector (GE)

Auto ignition operates in any of the following cases:

- Flameout is detected.
- Nacelle anti-ice is on.
- Flaps are out of up.
- N2 RPM is below 50% during start.

The description below assumes the standby ignition selector is set to NORM and no electrical failures exist:

SINGLE When auto or continuous ignition operates in flight, both igniters are energized. When auto or continuous ignition operates on the ground, either igniter 1 or igniter 2 is energized—the selection is automatically swapped before each ground start.

BOTH When auto or continuous ignition operates, both igniters are energized.

Ignition Control – A PW Model:

Continuous ignition switch

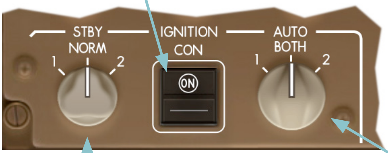
ON *Continuous* ignition operates.
A Sets approach idle limit.

Each engine is equipped with a pair of igniters, labeled as igniter 1 and igniter 2.

The ignition control on the overhead panel controls each engine's igniter pair.

Normally, on each engine, igniter 1 is powered by AC bus 1, and igniter 2 by AC bus 3.

Standby power to all igniters is provided by the main standby bus which uses the main battery as a backup.



Standby ignition selector (PW)

1 Ignition operates, even if auto and continuous ignition are off; *standby* power will energize igniter 1. If auto or continuous ignition is on, and auto is not set to 1, *normal* power will additionally energize igniter 2.

NORM Ignition operates when *normal* power to any igniter is lost, even if auto and continuous ignition are off; if it affects igniter 2 only, *standby* power will energize igniter 2; if it affects igniter 1 or both igniters, *standby* power will energize igniter 1.

2 Ignition operates, even if auto and continuous ignition are off; *standby* power will energize igniter 2. If auto or continuous ignition is on, and auto is not set to 2, *normal* power will additionally energize igniter 1.

Auto ignition selector (PW)

Auto ignition operates in any of the following cases:

- Nacelle anti-ice is on.
- Flaps are out of up.
- N2 RPM is below 50% during start.

The description below assumes the standby ignition selector is set to NORM and no electrical failures exist:

1 When auto or continuous ignition operates, igniter 1 is energized.

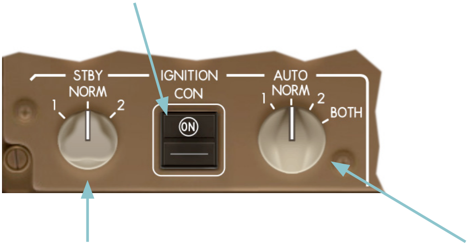
BOTH When auto or continuous ignition operates, both igniters are energized.

2 When auto or continuous ignition operates, igniter 2 is energized.

Ignition Control – A RR Model:

Continuous ignition switch

ON *Continuous* ignition operates.
A Sets approach idle limit.



Each engine is equipped with a pair of igniters, labeled as igniter 1 and igniter 2.

The ignition control on the overhead panel controls each engine's igniter pair.

Normally, on each engine, igniter 1 is powered by AC bus 1, and igniter 2 by AC bus 3.

Standby power to all igniters is provided by the main standby bus which uses the main battery as a backup.

Standby ignition selector (RR)

1 Ignition operates, even if auto and continuous ignition are off; *standby* power will energize igniter 1. If auto or continuous ignition is on, and auto is not set to 1, *normal* power will additionally energize igniter 2.

NORM Ignition operates when *normal* power to any igniter is lost, even if auto and continuous ignition are off; if it affects igniter 2 only, *standby* power will energize igniter 2; if it affects igniter 1 or both igniters, *standby* power will energize igniter 1.

2 Ignition operates, even if auto and continuous ignition are off; *standby* power will energize igniter 2. If auto or continuous ignition is on, and auto is not set to 2, *normal* power will additionally energize igniter 1.

Auto ignition selector (RR)

Auto ignition operates in either of the following cases:

- Flameout is detected.
- N3 RPM is below 50% during start.

The description below assumes the standby ignition selector is set to NORM and no electrical failures exist:

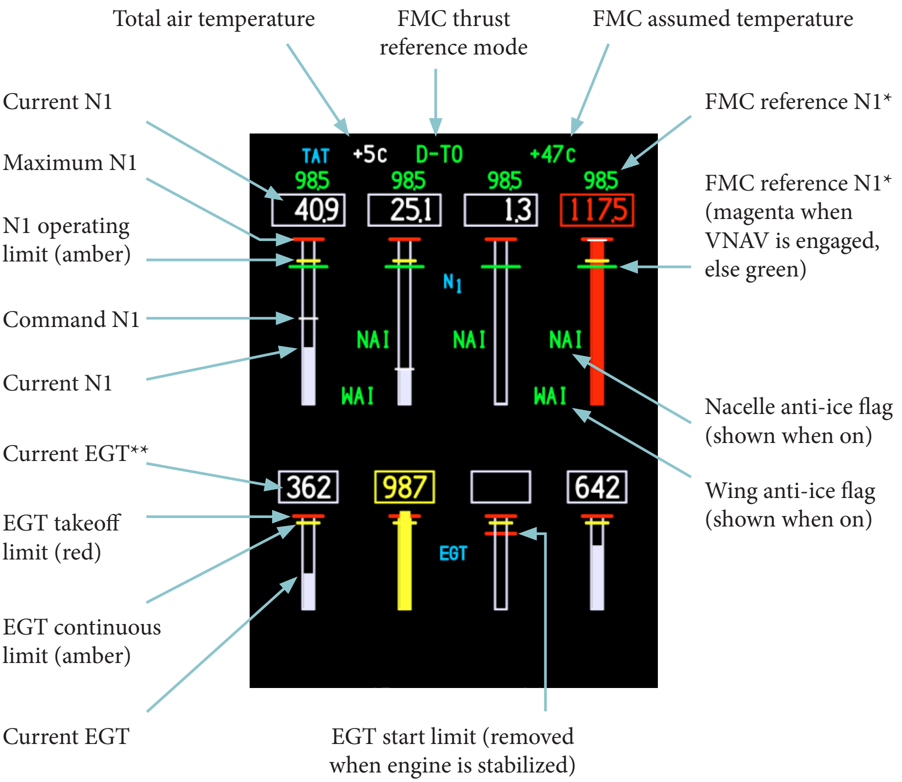
1 When auto or continuous ignition operates, igniter 1 is energized.

NORM When *continuous* ignition operates, both igniters are energized. Otherwise, when *auto* ignition operates, either igniter 1 or igniter 2 is energized—the selection is automatically swapped before each ground start.

2 When auto or continuous ignition operates, igniter 2 is energized.

BOTH When auto or continuous ignition operates, both igniters are energized.

Primary EICAS Display – A GE Model:

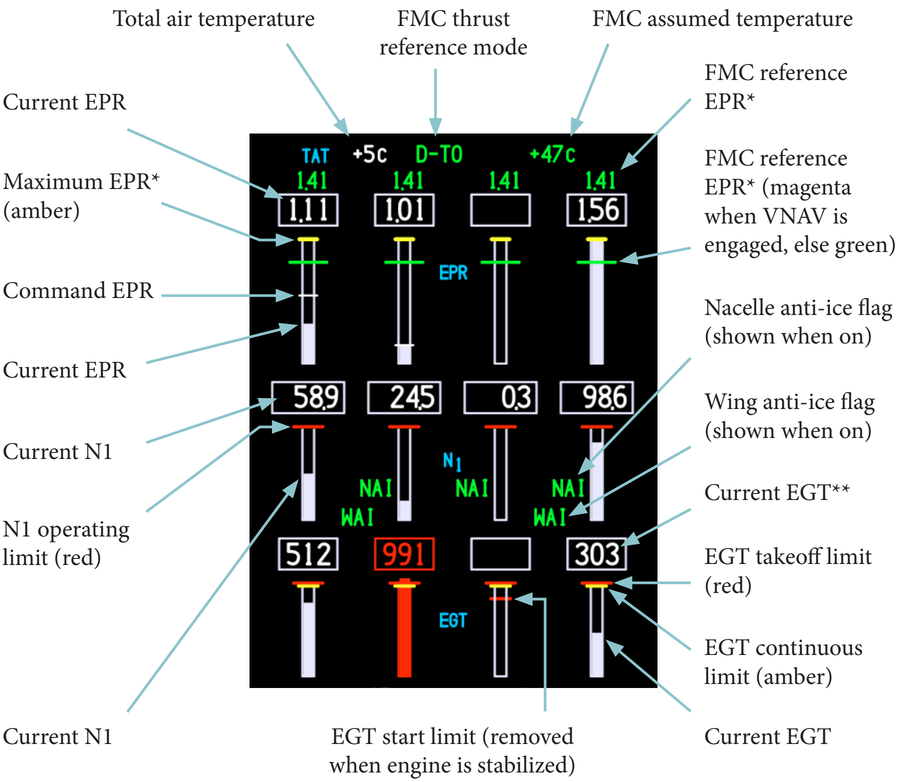


* *Removed when any engine is in thrust reverse mode.*
** *Once red, EGT box remains red; can be reset on **Instructor > Situation > Service: Erase latched messages** button. When EGT is above 999, first digit is suppressed.*

Current N1 is red when at maximum. EGT is amber at continuous limit. EGT exceedance turns red after 20 seconds. However, for takeoff and go-around the EGT remains white for 5 minutes (or for 10 minutes if an engine is inoperative).

EGT stands for exhaust gas temperature.

Primary EICAS Display – A *PW Model:*



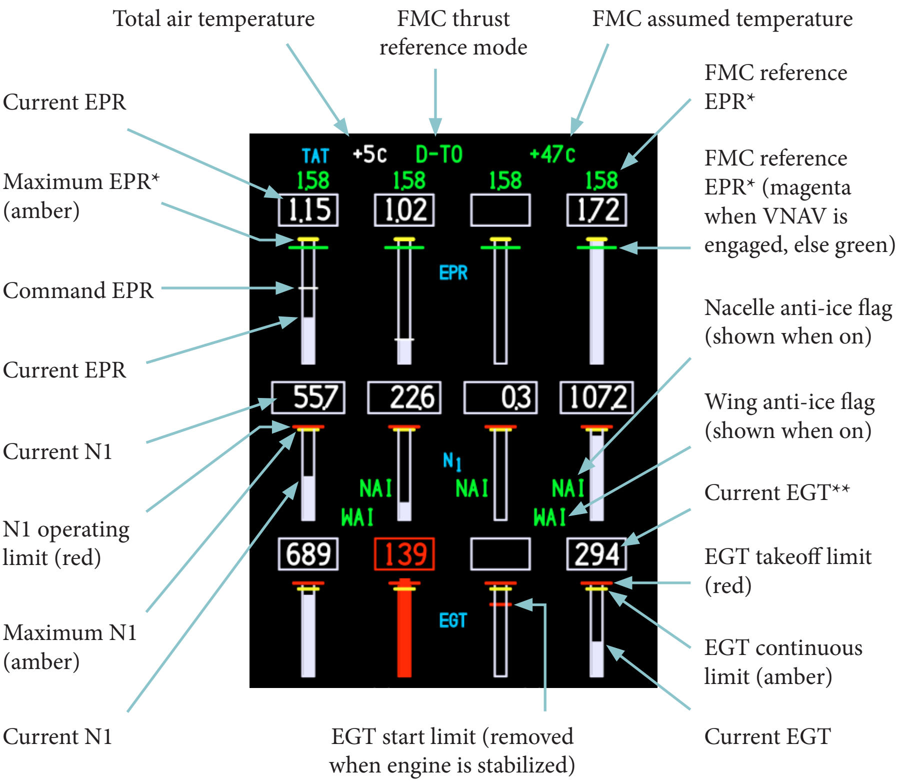
* *Removed when any engine is in thrust reverse mode.*
** *Once red, EGT box remains red; can be reset on **Instructor** > **Situation** > **Service**: **Erase latched messages** button. When EGT is above 999, first digit is suppressed.*

Current EPR, N1, or EGT is amber or red when respective limit is reached. EGT exceedance turns red after 20 seconds. However, for takeoff and go-around the EGT remains white for 5 minutes (or for 10 minutes if an engine is inoperative).

EPR stands for engine pressure ratio. PW systems use *core* EPR which is the ratio of the turbine exhaust pressure to the compressor inlet pressure. The EPR readout drops considerably when the Mach number rises. However, most of the total thrust is produced by the fan outlet pressure—this is disregarded in core EPR.

EGT stands for exhaust gas temperature.

Primary EICAS Display – A RR Model:



* *Removed when any engine is in thrust reverse mode.*

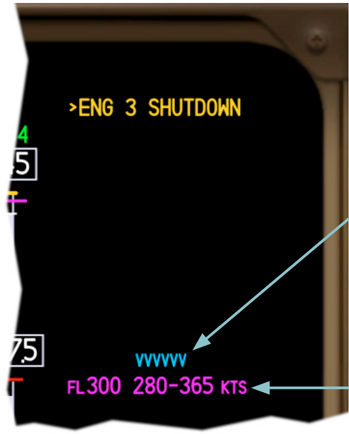
** *Once red, EGT box remains red; can be reset on **Instructor > Situation > Service: Erase latched messages** button. When EGT is above 999, first digit is suppressed.*

Current EPR, N1, or EGT is amber or red when respective limit is reached. EGT exceedance turns red after 20 seconds. However, for takeoff and go-around the EGT remains white for 5 minutes (or for 10 minutes if an engine is inoperative).

EPR stands for engine pressure ratio. RR systems use *integrated* EPR. This is the turbine exhaust pressure and fan outlet pressure both integrated on one side—in ratio to the compressor inlet pressure on the other side. This method, to a certain extent, prevents the EPR readout from decreasing when the Mach number rises.

EGT stands for exhaust gas temperature.

Primary EICAS Display – All Models:



Secondary engine exceedance cue
VVVVV is shown when a parameter on the secondary EICAS display is exceeding a limit. Replaces the cyan STATUS cue if indicated at the same time.

Inflight start envelope
Shown in flight when a fuel control switch is set to CUTOFF and the associated engine fire switch is in. Indicates the maximum flight level or the current flight level, whichever is lower, and the required IAS range for an inflight start at that level.

Secondary Engine Display:

Secondary engine display switch

First push Shows secondary engine indications on secondary EICAS display if display is available; otherwise shows compacted engine indications on primary EICAS display. Also shows duct pressure and cabin altitude indications on primary EICAS display.

Second push Removes engine indications from EICAS displays. Removes duct pressure and cabin altitude indications if parameters are in normal range.

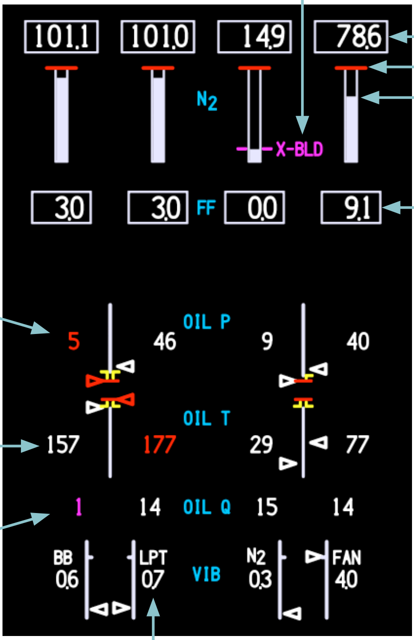
Secondary engine indications appear *automatically* in any of the following cases:

- EICAS is initially powered up.
- Any fuel control switch is set to CUTOFF in flight.
- Lower IDU was switched to ND or primary EICAS, and is now switched back to secondary EICAS.

Secondary Engine Display – A GE Model:

Fuel-on indicator (shows minimum N2 at which the fuel control switch should be set to RUN during start; blanks when set to RUN).

X-BLD flag is shown in flight when windmilling start is not possible and cross-bleed air is required for starter motor.



Current N2

N2 operating limit

Current N2

Fuel flow in:

A kg x 1000 / hour

A lb x 1000 / hour

Oil pressure in psi (caution range in amber, operating limit in red)

Oil temperature in °C (caution range in amber, operating limit in red)

Oil quantity in liters or US quarts (magenta when abnormal)

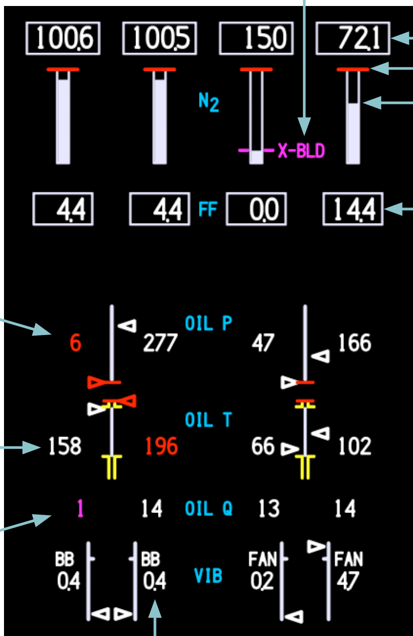
Highest vibration level and the related source:

- FAN (fan vibration)
- LPT (N1 rotor vibration)
- N2 (N2 rotor vibration)
- BB (broadband, source unknown)

Secondary Engine Display – A PW Model:

Fuel-on indicator (shows minimum N2 at which the fuel control switch should be set to RUN during start; blanks when set to RUN).

X-BLD flag is shown in flight when windmilling start is not possible and cross-bleed air is required for starter motor.



Current N2

N2 operating limit

Current N2

Fuel flow in:

A kg x 1000 / hour

A lb x 1000 / hour

Oil pressure in psi (operating limit in red)

Oil temperature in °C (caution range in amber, operating limit in red)

Oil quantity in liters or US quarts (magenta when abnormal)

Highest vibration level and the related source:

- FAN (fan vibration)
- LPT (N1 rotor vibration)
- N2 (N2 rotor vibration)
- BB (broadband, source unknown)

Secondary Engine Display – A RR Model:

Fuel-on indicator (shows minimum N2 at which the fuel control switch should be set to RUN during start; blanks when set to RUN).

X-BLD flag is shown in flight when windmilling start is not possible and cross-bleed air is required for starter motor.

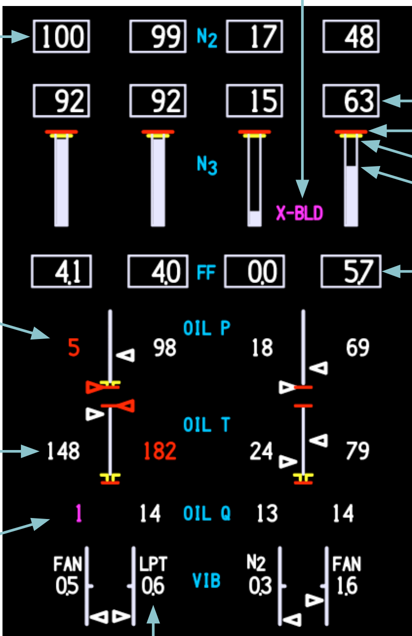
Current N2

Current N3

N3 operating limit

Maximum N3

Current N3



Fuel flow in:

- A kg x 1000 / hour
- A lb x 1000 / hour

Oil pressure in psi (caution range in amber, operating limit in red)

Oil temperature in °C (caution range in amber, operating limit in red)

Oil quantity in liters or US quarts (magenta when abnormal)

Highest vibration level and the related source:

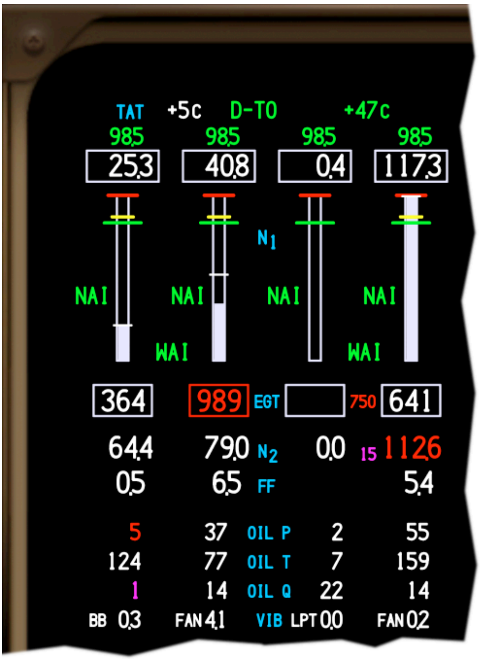
- FAN (fan vibration)
- LPT (N1 rotor vibration)
- N2 (N2 rotor vibration)
- N3 (N3 rotor vibration)
- BB (broadband, source unknown)

Compact Engine Indications – A GE Model:

Shown when just one IDU is available for EICAS displays, and the secondary engine display is manually or automatically selected.

Some important limit markers are replaced by digital indications:

- A digital EGT start limit indication (red) replaces the EGT start limit marker.
- A digital fuel-on indication (magenta) replaces the fuel-on marker; and X-BLD, if indicated, is replaced by XB.

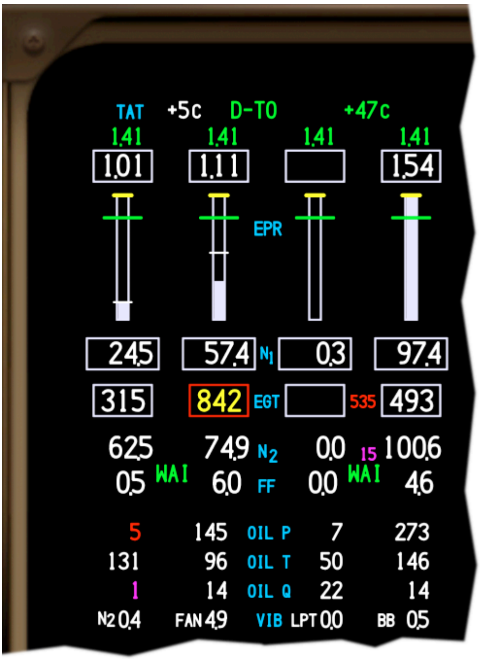


Compact Engine Indications – A PW Model:

Shown when just one IDU is available for EICAS displays, and the secondary engine display is manually or automatically selected.

Some important limit markers are replaced by digital indications:

- A digital EGT start limit indication (red) replaces the EGT start limit marker.
- A digital fuel-on indication (magenta) replaces the fuel-on marker; and X-BLD, if indicated, is replaced by XB.

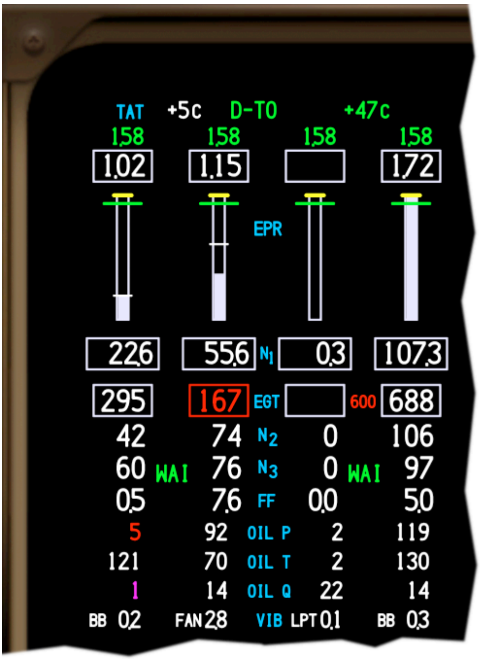


Compact Engine Indications – A RR Model:

Shown when just one IDU is available for EICAS displays, and the secondary engine display is manually or automatically selected.

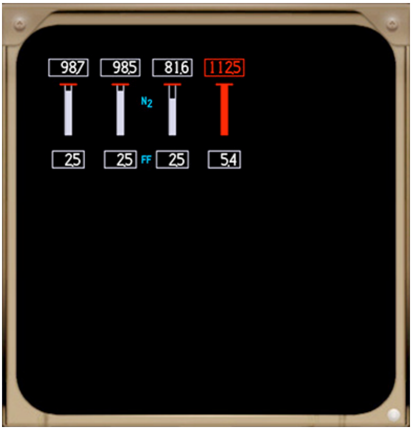
Some important limit markers are replaced by digital indications:

- A digital EGT start limit indication (red) replaces the EGT start limit marker.
- A digital fuel-on indication (magenta) replaces the fuel-on marker; and X-BLD, if indicated, is replaced by XB.



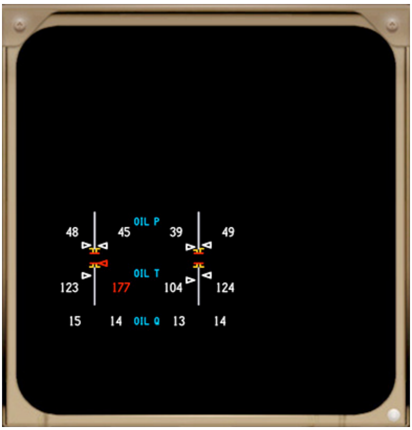
Partial Engine Indications:

A The examples below refer to GE indications.
PW and RR indications vary accordingly.

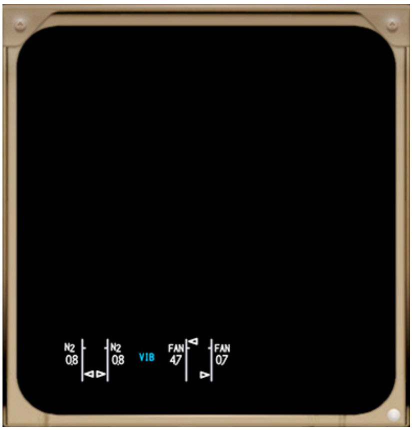


Partial display with N2 (and N3) and FF.

If the secondary engine display is not shown while an engine exceedance occurs, and two IDUs are available for EICAS displays, a *partial* display appears automatically on the secondary EICAS. There are three parts: the thrust data part, the oil data part, and the vibration data part. Only that part appears which contains the exceedance. When the display is manually deselected, the partial display will appear a second time when the exceeding parameter has returned to a normal value.



Partial display with oil data.

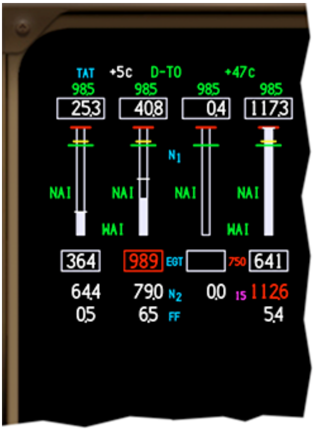


Partial display with vibration data.

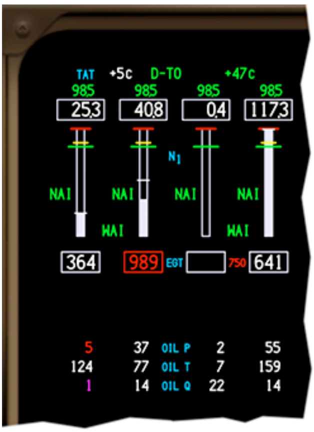
Partial Compact Engine Indications:

The examples below refer to GE indications. PW and RR indications vary accordingly.

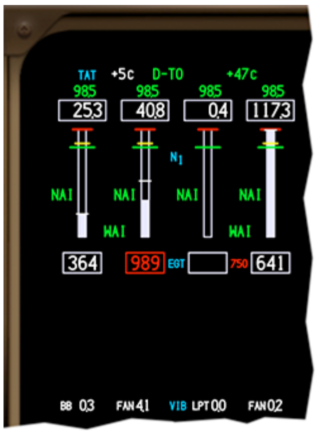
If the secondary engine display is not shown while an engine exceedance occurs, and just one IDU is available for EICAS displays, a *partial compact* display appears automatically on that IDU. There are three parts: the thrust data part, the oil data part, and the vibration data part. Only that part appears which contains the exceedance. When the display is manually deselected, the partial display will appear a second time when the exceeding parameter has returned to a normal value.



Partial display with N2 (and N3) and FF.



Partial display with oil data.



Partial display with vibration data.

EICAS Messages:

CAUTION MESSAGES (accompanied by caution light and beeper sound)		
ENG () AUTOSTART		engine (1, 2, 3, or 4) autostart failure during start
ENG () FAIL		engine (1, 2, 3, or 4) flameout detected
>ENG () LIM PROT		engine (1, 2, 3, or 4) N1 RPM above operating limit while EEC is in alternate mode
>ENG () SHUTDOWN		engine (1, 2, 3, or 4) fire switch is pulled OR fuel control switch is set to CUTOFF *[inhibits other engine related messages, and does not trigger caution light and beeper]*
STARTER CUTOUT ()		engine (1, 2, 3, or 4) { start valve fails to close OR switch fails to release } AND timeout exceeds A 5 seconds (GE & PW models) A 9 seconds (RR model)

ADVISORY MESSAGES		
>AUTOSTART OFF		autostart is deactivated on at least one engine
ENG () EEC MODE	ALTN LIGHT	engine (1, 2, 3, or 4) EEC is in alternate mode
ENG () FUEL VLV		engine (1, 2, 3, or 4) fuel valve or spar valve not in commanded position
ENG () OIL FILT		engine (1, 2, 3, or 4) oil filter bypass is impending
ENG () OIL PRESS		engine (1, 2, 3, or 4) oil pressure reaches operating limit while engine is running
ENG () OIL TEMP		engine (1, 2, 3, or 4) oil temperature at caution range
ENG () REVERSER		engine (1, 2, 3, or 4) thrust reverser system fault AND aircraft is on the ground AND airspeed is below 80 kt
>ENG () RPM LIM		engine (1, 2, 3, or 4) thrust is limited by N2 operating limit
ENG () START VLV		engine (1, 2, 3, or 4) start valve or start switch disagrees with commanded position for 40 seconds *[inhibited by STARTER CUTOUT () message]*
ENG IGNITION		at least one engine running with ignition operating AND ignition not operating on all running engines
>IDLE DISAGREE		any engine's idle setting disagrees with command

EICAS Messages:

MEMO MESSAGES		
CON IGNITION ON		continuous ignition switch is set to ON *[inhibited by ENG IGNITION message]*
STBY IGNITION ON		standby ignition selector is not set to NORM

STATUS MESSAGES		
CON IGN ENG ()		engine (1, 2, 3, or 4) continuous ignition has failed
EEC () GND PWR		EEC (1, 2, 3, or 4) maintenance switch is set to TEST while N2 RPM is above 10% *[PW specific message]*
ENG () FUEL VLV		engine (1, 2, 3, or 4) fuel valve or spar valve not in commanded position
ENG () IGNITOR ()		engine (1, 2, 3, or 4) igniter (1 or 2) fails to light AND timeout exceeds 60 seconds (GE model) 3 seconds (PW model) 10 seconds (RR model)
ENG () OIL FILT		engine (1, 2, 3, or 4) oil filter bypass is impending
ENG () OIL PRESS		engine (1, 2, 3, or 4) oil pressure reaches operating limit while engine is running
ENG () REVERSER		engine (1, 2, 3, or 4) thrust reverser system fault
ENG () START VLV		engine (1, 2, 3, or 4) start valve or start switch disagrees with commanded position for 2 minutes
IDLE DISAGREE		any engine's idle thrust setting disagrees with commanded setting
OIL PRESS SNS ()		engine (1, 2, 3, or 4) not running AND oil pressure switch senses high oil pressure
REV () INTERLOCK		engine (1, 2, 3, or 4) reverser lever interlock fault AND timeout exceeds 70 seconds (PW model) 10 seconds (GE & RR models)

Limitations in the Simulator:

The messages ENG () CONTROL, FUEL FILT, LOW IDLE, EEC C1, ESCV, OVSP GOV, REV POS, SPEED CARD are not included as these faults are not modeled.

Warning Systems

EICAS Controls:

For EFIS/EICAS interface and display components, refer to chapter **Flight Instruments**.

Upper & lower IDU brightness controls
Set the brightness and stroke (line width) of the graphics on the upper and lower integrated display units (IDUs). The inner knob of the lower control sets the brightness of the weather radar or terrain image when an ND is shown on the lower IDU. In the normal configuration, the upper IDU shows the primary EICAS display, and the lower IDU the secondary EICAS display.

EICAS EIU selector

L, C, R The selected EIU provides data to the upper IDU—and to the lower IDU when it is not assigned to an ND.

AUTO Selects EIU L if it is operative, else EIU C if that is operative, else EIU R.

Event record switch

Push Stores a maintenance event record in nonvolatile EIU memory. *(In the simulator, stores a situation file on the hard disk, provided this function is enabled on **Instructor** > **Preferences** > **Basics**. The stored situation file name will include a time stamp like, for example, "--Event record 2014-MAY-07 07-46-15.situ", and will be listed under **Instructor** > **Situations** > **Load**.)*

EICAS Messages:

Warning message (red)
Highest priority alert; always at the top; cannot be removed by CANC switch.

Caution message (amber)
Second highest priority alert; shown below lowest warning message.

Advisory message (amber & indented)
Lowest priority alert; shown below lowest caution message.

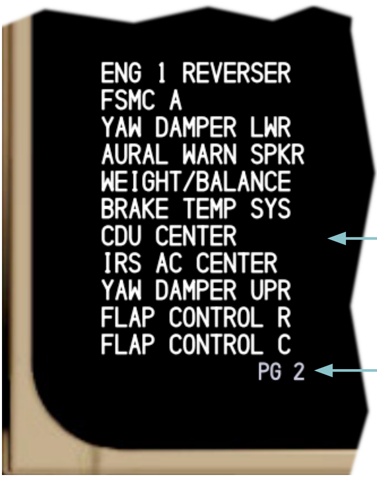
Memo message (white)
Reminder of a normal setting (no alert); shown at the bottom of the last page.

A caret “>” means the required crew action is obvious (no instructions in the quick reference handbook).

RECALL is shown for 1 second when the RCL switch has been pushed.

Current page number is shown when multiple pages exist.

STATUS is shown when a status message has been added. Blanks when the status display is selected, or when an engine starter cutout failure occurs. Replaced by VVVVV when a limit is exceeded on the secondary engine display.



Status messages are shown on the secondary EICAS when the status display is selected . Status messages indicate dispatch relevant faults.

Current page number is shown when multiple pages exist.

EICAS Messages:

Status display switch

Push Shows the status display on the secondary EICAS. If more than 11 status messages exist, each push selects the next page of status messages, or—when the last page is shown—removes the entire status display from the secondary EICAS.

If the condition that has generated a status message no longer exists, the system will, in most cases, erase that message. Certain status messages, however, will be latched (remain displayed). *(In the simulator, these can be erased on **Instructor** > **Situation** > **Service** with the button **Erase latched messages**).*

Cancel & recall switches

Push When more alert and memo messages exist than can be listed on one page, multiple pages are created. In such a case, pushing the RCL switch (recall) selects the first page; thereafter, every push of the CANC switch (cancel) selects the next page, and—when the last page is shown—blanks the remaining caution and advisory messages.

Whenever an alert message is added, it appears on the *currently* displayed page (at the top of the associated priority group), even if the page displayed is not the first page. Pushing the CANC or RCL switch will then move the new message to the actual chronological position.

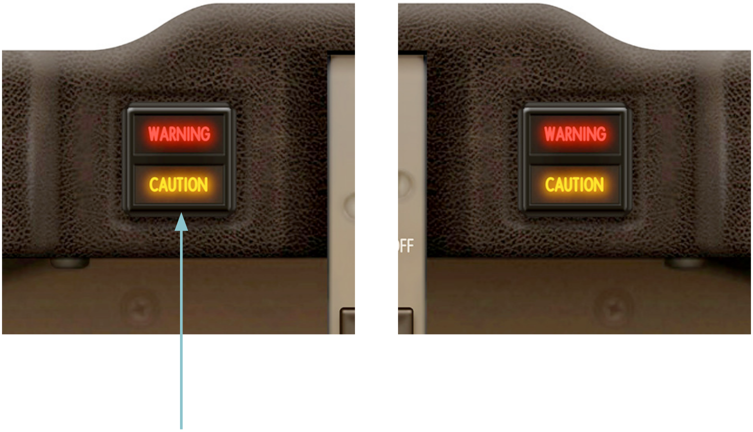
When more than 10 *warning* messages exist, the screen always shows page 1, and the cancel function is inhibited.

Pushing the CANC switch also whites out all red EGT boxes—but does not erase the EGT exceedances from the fault memory. Pushing the RCL switch redisplays all stored exceedances, that is: redisplays all red EGT boxes.

For Engineers

When the status display is selected, and the last page of status messages is shown, and the CMCs are shut down, all latched status messages and red EGT boxes can be erased by pushing and holding the CANC and RCL switches simultaneously for 3 seconds. *(In the simulator, the condition of the CMCs being shut down is not required.—Place the mouse cursor between the two switches, then hold the left mouse button.)*

EICAS Messages:



Master warning/caution reset switch (left, right)

Push (momentary action) Extinguishes the red and amber lights in both switches. Allows future alerts to re-illuminate the lights. Silences the fire bell, the cabin altitude siren, and—if the flap lever is not set to 25 or 30—the inflight gear configuration siren.

WARNING LIGHT An EICAS warning message has been added, or the EGPWS is signalling a “pull up!” warning, or any reactive or predictive windshear warning is active.

CAUTION LIGHT An EICAS caution message has been added.

EICAS Messages:

Modularized avionics warning electronics assembly (MAWEA)

Various electronic cards are installed in the MAWEA; some provide the alert sounds to the flight deck speakers; some other cards contain the system logic for stall warnings, for takeoff and landing configuration alerts, for alert inhibits, and many other functions.

EICAS aural alerts

A **bell** rings every five seconds when a fire warning message is present. The first ring is louder than the subsequent rings. The bell silences when the crew pushes a master warning reset switch, or when the fire is extinguished.

A two-tone **siren** sounds continuously for warning messages related to:
- Takeoff configuration (siren cannot be silenced)
- Mach/IAS overspeed (siren cannot be silenced)
- Cabin altitude (siren can be silenced by master warning reset switch)
- Landing configuration (siren can be silenced in specific ways; refer to next pages)

A continuously repeated, up-sliding tone—called **wailer**—accompanies the autopilot disconnection warning. The wailer can be silenced by pushing the autopilot disconnect switch a second time. *(In the simulator, the autopilot disconnect switch is the A-key on the PC keyboard, or a user defined USB button, or a button connected via TCP/IP. The wailer can also be silenced on **Instructor > Situation > Service** by pushing the button **Erase latched messages**.)*

A one-time series of four short tones—called **beeper**—sounds for all caution messages except for >ENG () SHUTDOWN messages.

Four-engine shutdown alert inhibit

When the aircraft is on the ground and all engines are shut down, new caution messages may appear on the EICAS, but they will not illuminate the master caution lights, and the beeper will not sound.

Engine start alert inhibit

While the engine start switch is pulled and latched, and the engine is not running, the system will inhibit all new caution and advisory messages except for:

BLEED ()
ENG () AUTOSTART
ENG () FUEL VLV
ENG () SHUTDOWN
ENG () START VLV
STARTER CUTOUT ()

(continued next page)

EICAS Messages: *(continued)*

Starter cutout alert inhibit

When the starter fails to cut out during engine start, the caution message STARTER CUTOUT () will be displayed. All other existing caution messages will be removed. All advisory and memo messages will be removed and inhibited. The inhibit ends when any of the following conditions is true:
- 20 seconds have passed since the cutout failure occured.
- Another caution message is added.
- The CANC switch is pushed.
- The RCL switch is pushed.

Takeoff alert enable logic

This feature enables EICAS configuration warnings for the takeoff phase.

When the FMC provides a valid V1 speed, the takeoff alert is enabled when these two conditions are true:
+ Air-ground relays are in ground mode
+ Takeoff phase warning inhibit is off

When V1 is invalid, the takeoff alert is enabled when all of the following conditions are true:
+ Radio altimeters L & R are inoperative or RA is below 15 ft
+ Air-ground relays are in ground mode
+ Takeoff phase warning inhibit is off

When V1 is invalid and air-ground relays fail, the takeoff alert is enabled when all of these conditions are true:
+ Radio altimeter L or R is operative and RA is at or below 0 ft
+ IRS pitch attitude is valid and below 5°
+ Takeoff phase warning inhibit is off

Once the takeoff alert is enabled, it remains enabled even if V1, RA, and air-ground data become invalid thereafter. It remains enabled until the takeoff phase warning inhibit begins.

(continued next page)

EICAS Messages: *(continued)*

Takeoff phase warning inhibit

This feature inhibits EICAS warnings during the critical phase of the takeoff.

When the FMC provides a valid V1 speed, the takeoff phase warning inhibit begins when these two conditions are true:
+ Takeoff alert is enabled
+ ADC computed IAS is valid and greater than V1

When V1 is invalid, the takeoff phase warning inhibit begins when these two conditions are true:
+ Takeoff alert is enabled
+ IRS pitch attitude is valid and above 5°

Once the takeoff phase warning inhibit has begun, it remains on until either of these conditions is true:
- 25 seconds have passed since the beginning of the warning inhibit
- Radio altimeter L or R is operative and RA is above 400 ft

Takeoff phase caution inhibit

The takeoff phase caution inhibit deactivates the beeper and the master caution lights.

The takeoff phase caution inhibit begins when these two conditions are true:
+ Radio altimeters L & R are inoperative or RA is below 400 ft
+ ADC computed IAS is valid and rises through 80 kt

The takeoff phase caution inhibit ends when any of these conditions is true:
- 20 seconds have passed since the IRS pitch attitude rotated through 5°
- Radio altimeter L or R is operative and RA is above 400 ft
- ADC computed IAS is valid and below 75 kt
- ADC computed IAS is invalid

The beeper will sound and the caution lights will illuminate when the takeoff phase caution inhibit ends while a caution message already exists.

(continued next page)

EICAS Messages: *(continued)*

Takeoff configuration warning messages

When a takeoff roll is started, the following warning messages may appear:
CONFIG FLAPS if the flaps are not in a takeoff position.
CONFIG GEAR CTR if the body gear is not centered.
CONFIG PARK BRK if the parking brake is set.
CONFIG SPOILERS if the speedbrakes are not down.
CONFIG STAB if the stabilizer trim is not within the green band.

A takeoff roll is considered started when all of the following conditions are true:
+ EEC indicates engines 2 and 3 thrust is in takeoff range
+ Engines 2 and 3 reversers are retracted
+ More than 2 engine fuel control switches are set to RUN
+ Takeoff alert is enabled

Landing configuration warning message

The warning message CONFIG GEAR appears in flight when the landing gear is not down and locked, and 140 seconds have passed since the initial gear retraction, and either of these conditions is true:

- Any thrust lever is at idle and RA is below 800 ft
- Flap lever is set to 25 or 30

When the flap lever is set to 25 or 30, the siren for the CONFIG GEAR message can only be silenced by the gear alert override switch. Otherwise, it can also be silenced by the master warning reset switches.

Stall Warning:

A stick shaker motor is attached to each pilot's control column (stick) to provide a tactile warning in case of an impending stall. The MAWEA contains two identical stall warning computers, each controlling both stick shaker motors. The difference between the stick shaker speed and the actual stall speed depends on the current flap setting; the greatest difference is 26 kt when the flaps are up, the lowest 6 kt at flap 30.

Alert Inhibit Switches:

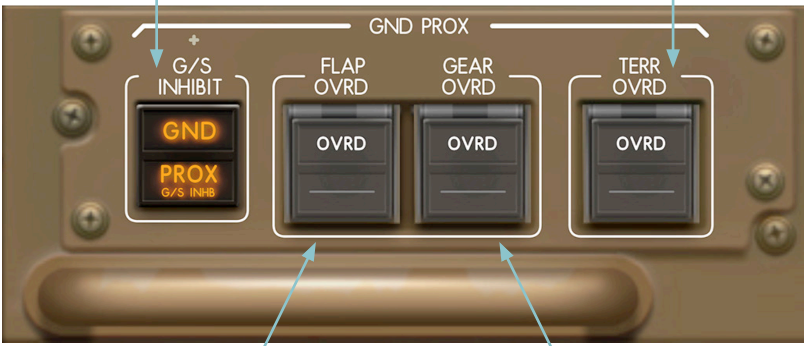
Glideslope alert inhibit switch

Push (momentary action) Inhibits the EGPWS "glideslope!" alert.

AMBER LIGHT Any EGPWS ground proximity caution exists.

Terrain alert override switch (guarded)

OVRD Inhibits alerts which work with EGPWS databases. Also blanks the EGPWS terrain map on the NDs.



Flap alert override switch (guarded)

OVRD Inhibits the EGPWS "too low, flap!" alert.

Gear alert override switch (guarded)

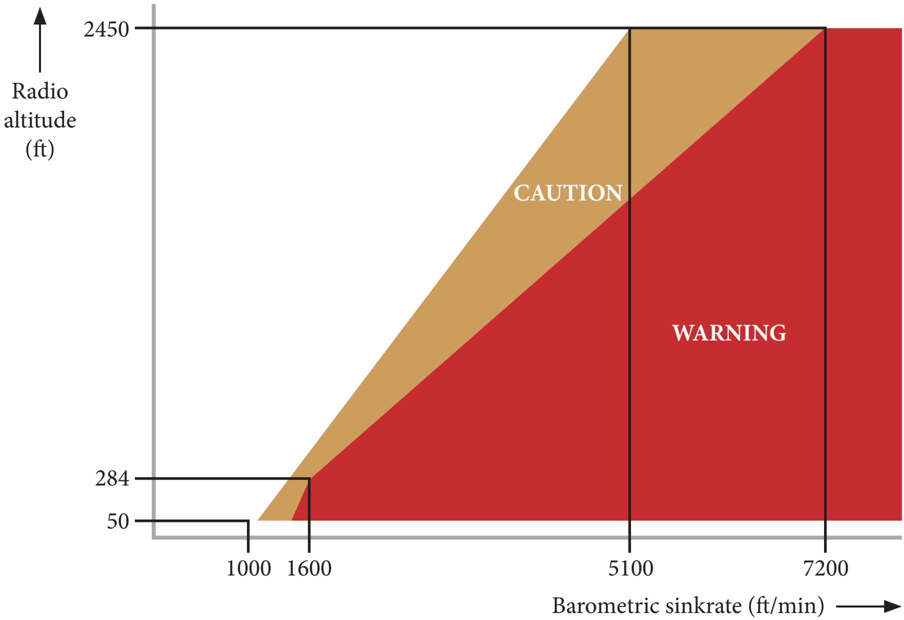
OVRD Inhibits the EGPWS "too low, gear!" alert and the EICAS landing configuration warning.

EGPWS:

The aircraft is equipped with an enhanced ground proximity warning system (EGPWS) which is an upgrade to the GPWS. Either system alerts the crew to critical *vertical* ground proximities (modes 1 to 7), but the EGPWS also alerts to *horizontal* proximities: it is able to look ahead using an integrated worldwide terrain database (and, optionally, some regional obstacle databases). It receives aircraft position data from the GPS when available, else from IRU L when aligned, else from IRU R.—The following functions, among others, are included in the EGPWS:

- **Mode 1** – excessive barometric sinkrate alert.
- **Mode 2** – excessive radio altitude rate alert.
- **Mode 3** – altitude loss alert during takeoff or go-around.
- **Mode 4** – landing configuration alert.
- **Mode 5** – glideslope alert.
- A **Mode 6** – height and bank angle callouts.
- A **Mode 7** – reactive windshear alert.
- **Terrain clearance floor (TCF)** – landing-short-of-runway alert, regardless of landing configuration and glideslope signals; uses a worldwide runway database integrated in the EGPWS, and an algorithm to determine the target runway.
- **Terrain look ahead alerting** – collision alert based on the predicted aircraft path and the integrated terrain database.
- **Terrain alerting & display (TAD)** – shows, on the NDs, surrounding terrain down to 2000 ft below the aircraft; uses specific colors and dot patterns for various alert levels.
- A **Peaks display** – optional TAD function; always shows highest terrain in the vicinity, regardless of aircraft altitude.
- **Aural message priority** – priority system to avoid aural clutter when multiple alerts are triggered simultaneously.

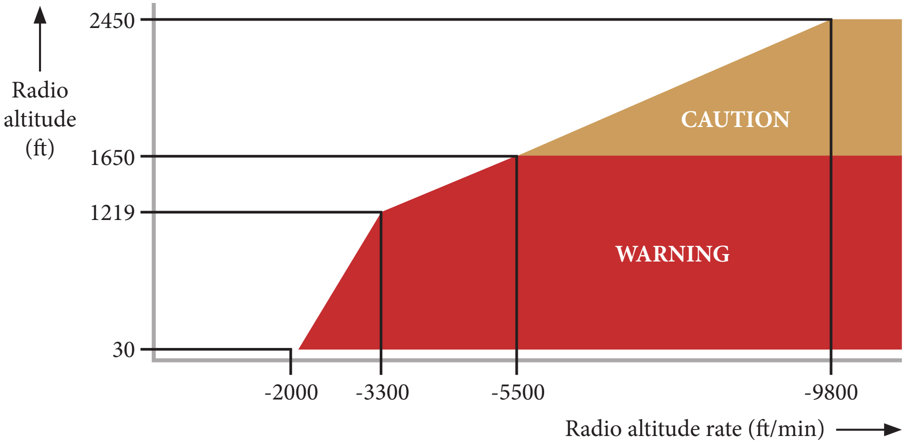
EGPWS – Mode 1:

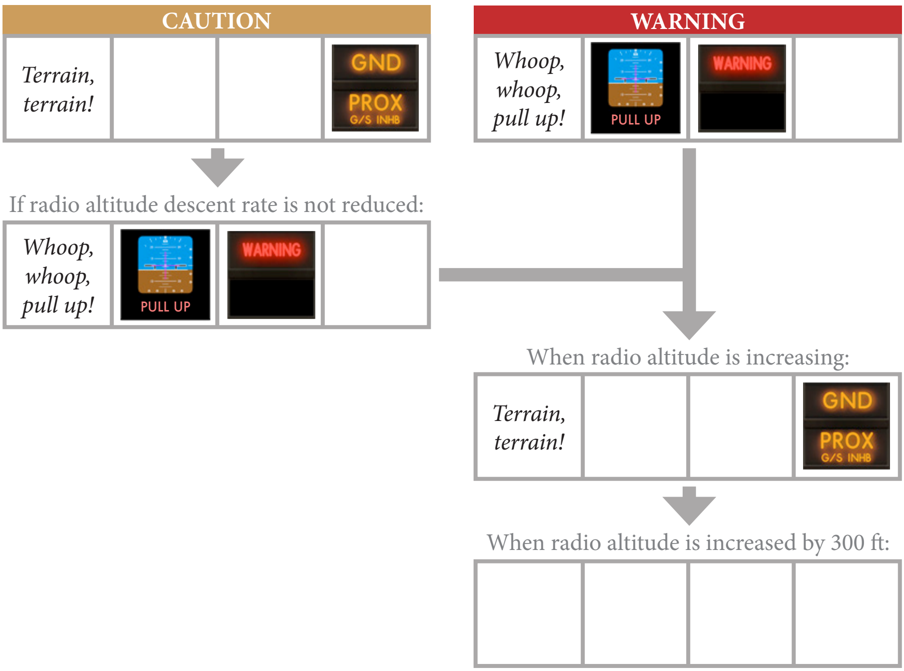


CAUTION			
Sinkrate!			

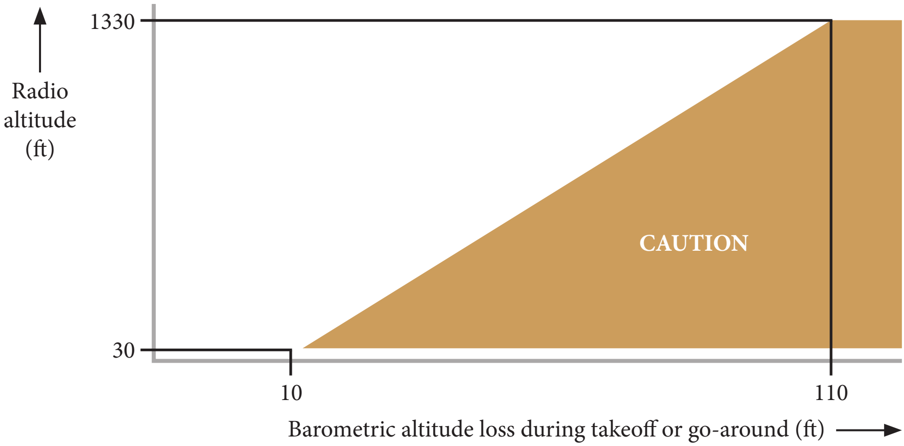
WARNING			
Whoop, whoop, pull up!			

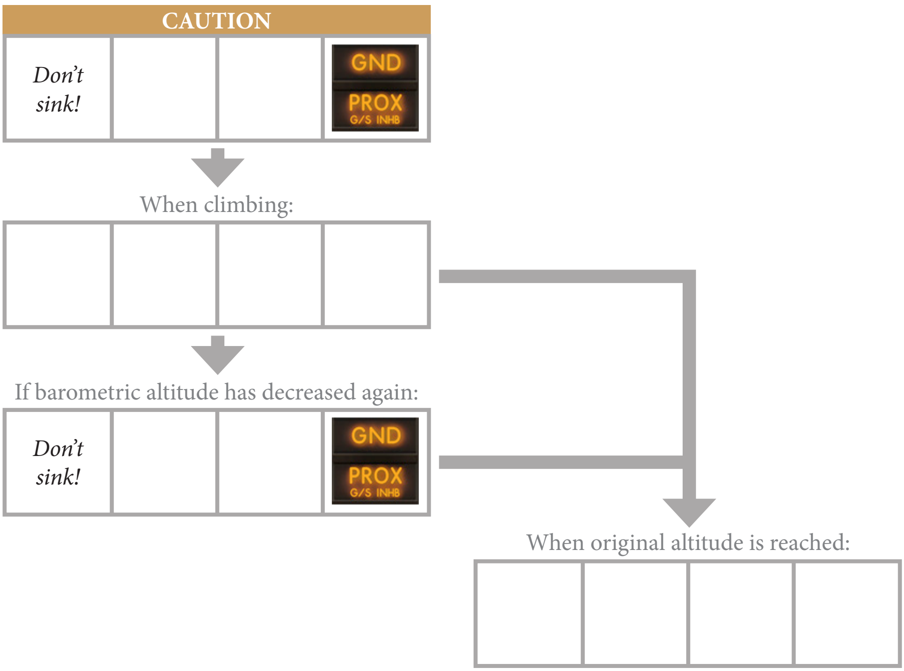
EGPWS – Mode 2:


2450
1650
1219
30
Radio altitude (ft)
CAUTION
WARNING
-2000
-3300
-5500
-9800
Radio altitude rate (ft/min)

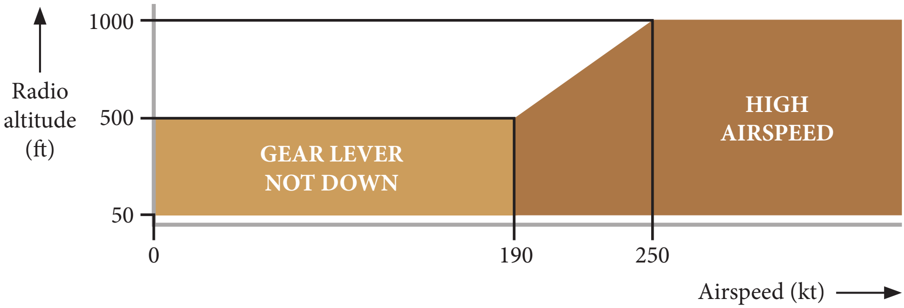

CAUTION
Terrain, terrain!
GND PROX G/S INHB
If radio altitude descent rate is not reduced:
Whoop, whoop, pull up!
PULL UP
WARNING
WARNING
Whoop, whoop, pull up!
PULL UP
WARNING
When radio altitude is increasing:
Terrain, terrain!
GND PROX G/S INHB
When radio altitude is increased by 300 ft:

EGPWS – Mode 3:


1330
30
Radio altitude (ft)
CAUTION
10
110
Barometric altitude loss during takeoff or go-around (ft)


CAUTION
Don't sink!
GND PROX G/S INHB
When climbing:
If barometric altitude has decreased again:
Don't sink!
GND PROX G/S INHB
When original altitude is reached:

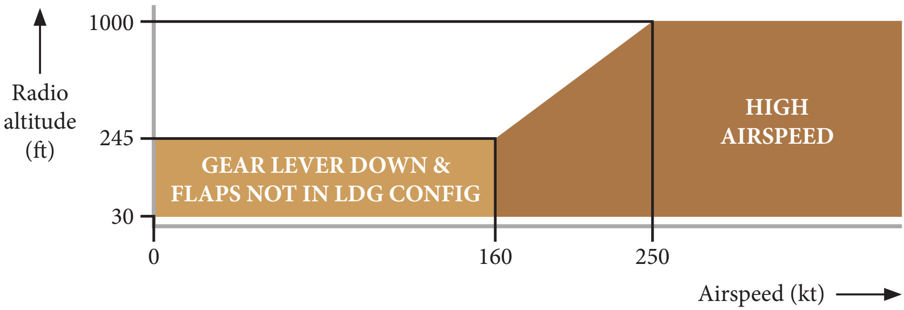
EGPWS – Mode 4a:



GEAR LEVER NOT DOWN			
Too low, gear!			

HIGH AIRSPEED			
Too low, terrain!			

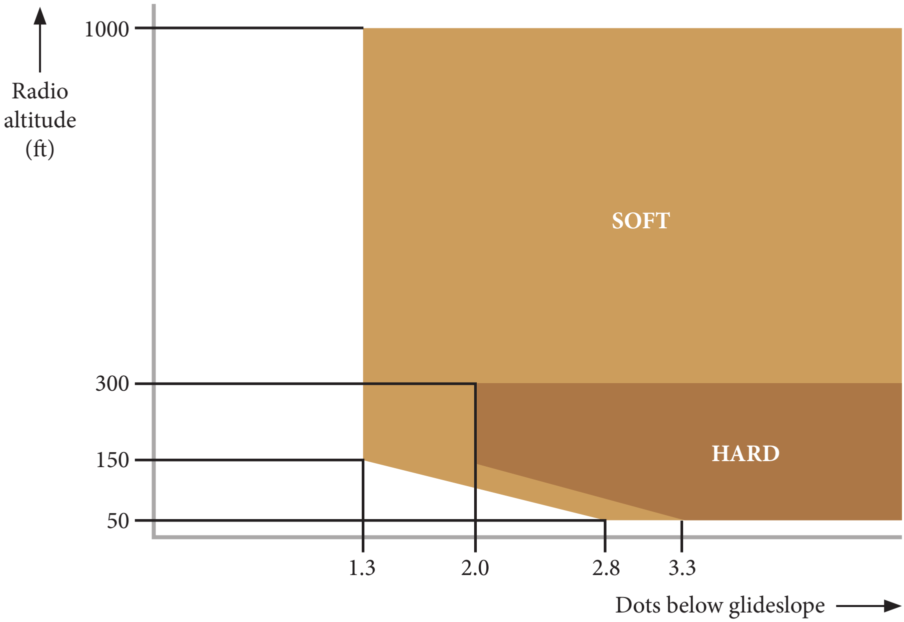
EGPWS – Mode 4b:



FLAPS NOT IN LDG CONFIG			
Too low, flaps!			

HIGH AIRSPEED			
Too low, terrain!			

EGPWS – Mode 5:



SOFT			
Glide-slope! (half volume)			

HARD			
Glide-slope! (loud)			

EGPWS – Mode 6:

Mode 6 includes the following altitude call-outs. Each call-out is optional:
"Radio altimeter!" or *"Twenty-five hundred!"* at 2500 ft RA.
"One thousand!" at 1000 ft RA.
"Five hundred!" at 500 ft above field elevation for non-precision approach.
"Four hundred!" at 400 ft RA.
"Three hundred!" at 300 ft RA.
"Two hundred!" at 200 ft RA.
"One hundred!" at 100 ft RA.
"Fifty!" at 50 ft RA.
"Forty!" at 40 ft RA.
"Thirty!" at 30 ft RA.
"Twenty!" at 20 ft RA.
"Ten!" at 10 ft RA.
"Plus hundred!" at 100 ft above radio minimum.
"Fifty above!" at 50 ft above radio minimum.
"Decide!" or *"Minimums!"* at radio minimum.

Flare tones, optionally, sound at 100, 35, and 20 ft RA.

Optionally, the call-out *"Bank angle, bank angle!"* sounds when the aircraft exceeds the bank angle limit. The limit is 5° when below 30 ft RA, or 35° when above 150 ft RA, else the limit rises from 5° to 35° between 30 ft and 150 ft RA. The call-out is repeated when the limit plus 5° is exceeded, and again when the limit plus 10° is exceeded. The call-out is re-armed when the bank angle is less than the limit minus 4°.

EGPWS – Mode 7:

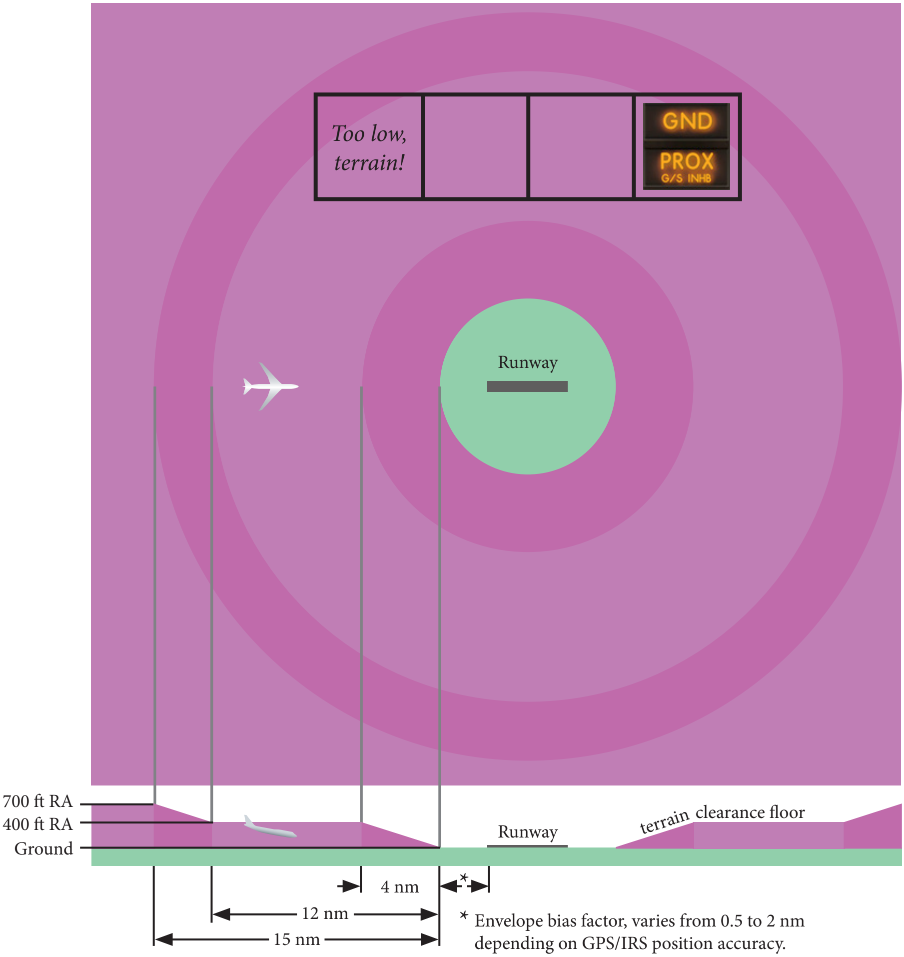
Mode 7 is a *reactive* windshear alert, enabled below 1500 ft RA.

POSITIVE WINDSHEAR			
			

NEGATIVE WINDSHEAR			
2 tones & 3x *"Wind-shear!"*			

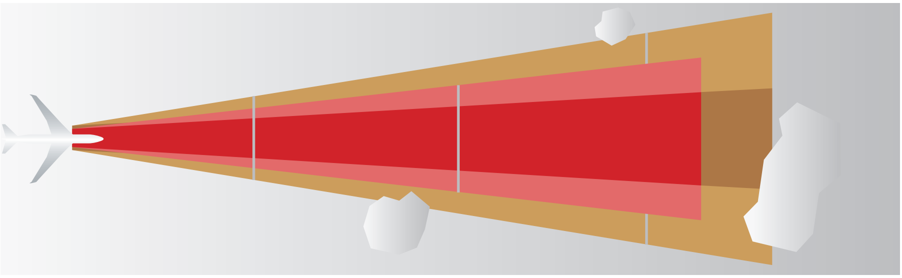
EGPWS – Terrain Clearance Floor:

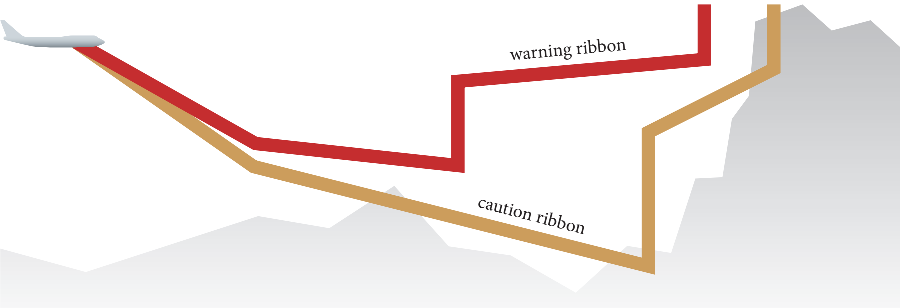
The ground proximity light illuminates and *"Too low, terrain!"* sounds repeatedly when the EGPWS predicts the aircraft is about to land short of the runway; that is, when the aircraft is below the terrain clearance floor that the EGPWS constructs around the target runway. This function is independent of the landing configuration, glideslope signal, and FMC runway: the EGPWS uses its own worldwide runway database, and applies a special algorithm to determine the target runway.



EGPWS – Terrain Look Ahead Alerting:

This function constructs caution and warning "ribbons" along the predicted flight path; they have a specific form, and move with the aircraft. When the local terrain, loaded from the EGPWS database, intersects a ribbon, the respective caution or warning is triggered. The ribbons rotate vertically with the aircraft flight path angle, and expand forward with rising groundspeeds. They are, laterally, 0.25 nm wide at the aircraft, and widen further along the path, 3° to the left and right—greater angles are used during turns. The caution typically activates 60 seconds before the collision; 30 seconds are given for the warning. To avoid nuisance alerts during takeoff and approach, the ribbons are modified in the vicinity of the detected target runway.





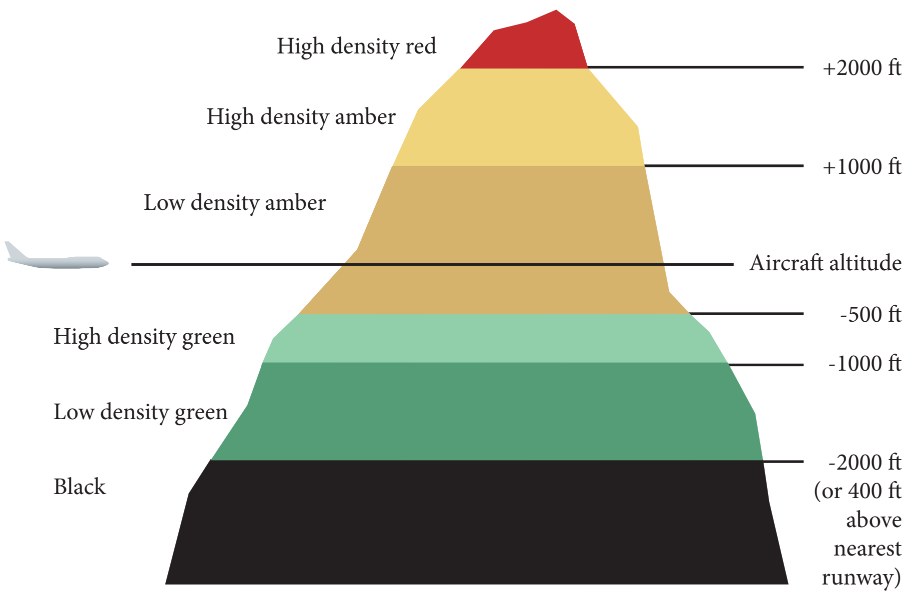
CAUTION			
Caution, terrain! Caution, terrain!			

WARNING			
Whoop, whoop, pull up!			

EGPWS – Terrain Alerting & Display:

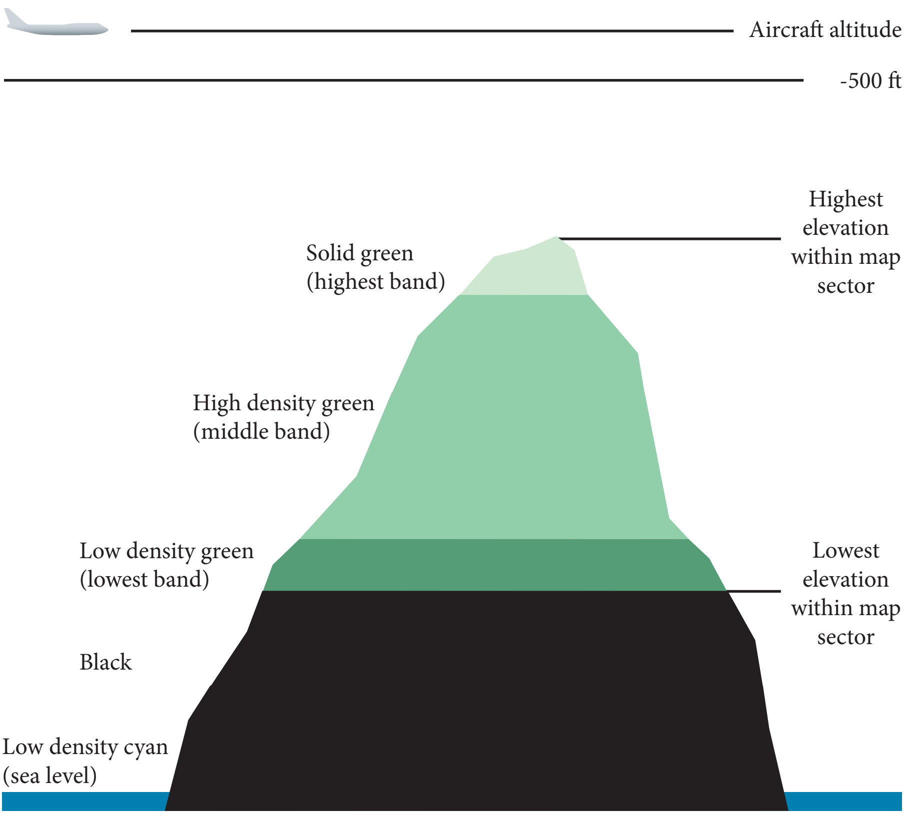
This function generates terrain raster images on the NDs when TERR is selected on the EFIS control, or when a terrain look ahead alert sounds. The image is sent through the same raster data bus the weather radar uses, and is continuously updated by left and right sweeps, similar to radar sweeps. To prevent confusion with the radar raster, the EGPWS uses special dot patterns. Also, unlike the radar raster, the terrain raster is composed of tiles; the lower the ND range, the larger the tiles.—A dot pattern has either a high or a low dot density; high density patterns appear brighter than low density patterns. *(In the simulator, the dots are slightly enlarged and blurred in order to avoid flickering moiré effects during map motion.)*

When a terrain look ahead caution exists, the predicted collision area is shown in solid amber; respectively, in solid red if it is a warning. The solid colored areas provide the highest brightness. During the alert, the NDs also show the word TERRAIN in amber or red, according to the current alert level.



EGPWS – A Peaks Display:

The peaks display feature is an option of the terrain display function. It provides two digital displays in the lower left corner of the NDs, indicating the elevation numbers in hundreds of feet for the highest peak and the lowest ground within the currently shown map sector. Besides, the peaks display adds a solid green color level—and, also optionally, a cyan low density dot pattern for sea level areas. These additional color levels just occur when no amber and no red areas are present. Moreover, the sea level areas only appear when the map sector currently shown includes a coastline.



EGPWS – Aural Message Priority:

To avoid aural clutter, a priority system is applied to all EGPWS messages. When more than one alert is triggered at a time, just the message with the highest priority will sound—and it will sound immediately: it will interrupt any existing lower priority message. The following list shows the order of the priority, starting with the highest priority at the top:

“Windshear, windshear, windshear!”

“Pull up!”

“Terrain, terrain!”

“Decide!” or *“Minimums!”*

“Caution, terrain! Caution, terrain!”

“Too low, terrain!”

Altitude call-outs

“Too low, gear!”

“Too low, flaps!”

“Sinkrate!”

“Don’t sink!”

“Glideslope!”

“Fifty above!”

“Plus hundred!”

“Bank angle! Bank angle!”

Predictive Windshear System:

General

Unlike the *reactive* windshear system of the EGPWS, the *predictive* windshear system (PWS) is a function of the weather radar system and is able to alert the crew *before* a windshear zone is entered. It shows the detected windshear zones on the NDs, and triggers aural alerts when a windshear zone is located near the current flight track.

Technology

The PWS can detect windshears just in areas where precipitation exists. The radio frequency of radar returns from water drops is higher when the drops move toward the aircraft, and is lower when moving away from the aircraft (Doppler effect). This way, the radar system can compute the speeds of air masses at several locations within the scope of the radar.

Enablement

The PWS is enabled when any of these conditions is true:

- Aircraft is in flight and below 2300 ft RA.
- Aircraft is on the ground and takeoff thrust is set.
- Aircraft is on the ground and WXR is selected on the EFIS control.

When initially enabled on the ground, it may take up to 12 seconds of sweep time until the radar can provide windshear alerts for the area ahead. Therefore, when windshear conditions exist, the crew should manually activate the radar as soon as the takeoff position is reached; the automatic enable logic by takeoff thrust detection is just a backup function.

Alerts

The PWS can generate alerts when the aircraft is below 1200 ft RA. When WXR is selected on the EFIS control, pushing the TEST switch on the weather radar control panel starts a radar test; this will include an alert system test. Windshear zones appear on the ND maps in form of red-striped sectors accompanied by amber radials at the sector edges. There are two alert levels: caution level and warning level. The level depends on the location of the predicted windshear zone. The NDs show the word WINDSHEAR in amber or red according to the alert level. The red master warning lights illuminate for warnings.

Aural messages sound in the following cases:

- *"Monitor radar display!"* for cautions in all flight phases.
- *"Windshear ahead! Windshear ahead!"* for warnings during takeoff roll.
- *"Go around! Windshear ahead!"* for warnings during the landing.
- *"Radar test terminated!"* when switching off a test before the system has completed the test.

TCAS:

General

The traffic alert and collision avoidance system (TCAS) measures the distances and closure rates between aircraft, and alerts the pilots when the risk of a collision exists. TCAS can indicate other aircraft on the NDs and, when necessary, display steering commands for escape maneuvers on the PFDs. Alerts are accompanied by aural messages.

Technology

To measure the distances and closure rates, TCAS continuously monitors the other aircraft's transponder signals. Bearing information is only required for the traffic display on the NDs, not for the alert system which is solely a function of distance and time (or just distance when traffic is very close). In addition, when the transponder signals include altitude information, TCAS can provide steering commands, called resolution advisories—these are also coordinated with the TCAS of the other aircraft. An RA is always a vertical maneuver.

Alerts

A TCAS alert is either a traffic advisory (TA) or a resolution advisory (RA). The alerts are enabled when the control selector on the transponder control panel is set to TA, or RA/TA, respectively (refer to **ATC Transponder System** in chapter **Navigation Systems**). Amber symbology is used for TAs, red symbology for RAs. The NDs also show the word TRAFFIC in amber or red accordingly. When an RA occurs, the crew should ignore the last ATC instruction and, instead, follow the TCAS command; the escape maneuver should be initiated immediately—the autopilot should be disconnected if required.

Aural TA messages sound in the following cases:

- *"Traffic, traffic!"* when traffic is within 20 to 48 seconds of the closest point of approach. This message is enabled above 600 ft radio altitude during climb, or above 400 ft radio altitude during descent.
- *"Clear of conflict!"* when an RA has been triggered and the conflict is now cleared. This message is enabled above 1100 ft radio altitude during climb, or above 900 ft radio altitude during descent.

(continued next page)

TCAS:

Alerts *(continued)*

Aural RA messages sound in the following cases:

- *"Climb, climb!"* when a climb is required. This message is enabled above 1100 ft radio altitude during climb, or above 900 ft radio altitude during descent.
- *"Descend, descend!"* when a descent is required. This message is enabled above 1200 ft radio altitude during climb, or above 1000 ft radio altitude during descent.
- *"Climb! Crossing climb! Climb! Crossing climb!"* when a climb is required, and the own path will cross the other aircraft's path. This message is enabled above 1100 ft radio altitude during climb, or above 900 ft radio altitude during descent.
- *"Descend! Crossing descent! Descend! Crossing descent!"* when a descent is required, and the own path will cross the other aircraft's path. This message is enabled above 1100 ft radio altitude during climb, or above 900 ft radio altitude during descent.
- *"Level off! Level off!"* when a climb or descent should be stopped. This message is enabled above 1100 ft radio altitude during climb, or above 900 ft radio altitude during descent.
- *"Increase climb! Increase climb!"* when the climb rate should be increased. This message is enabled above 1100 ft radio altitude during climb, or above 900 ft radio altitude during descent.
- *"Increase descent! Increase descent!"* when the descent rate should be increased. This message is enabled above 1650 ft radio altitude during climb, or above 1450 ft radio altitude during descent.
- *"Climb! Climb now! Climb! Climb now!"* when the previous RA was a descend advisory. This message is enabled above 1100 ft radio altitude during climb, or above 900 ft radio altitude during descent.
- *"Descend! Descend now! Descend! Descend now!"* when the previous RA was a climb advisory. This message is enabled above 1100 ft radio altitude during climb, or above 900 ft radio altitude during descent.
- *"Monitor vertical speed! Monitor vertical speed!"* when the current V/S should be maintained. This message is enabled above 1100 ft radio altitude during climb, or above 900 ft radio altitude during descent.

EICAS Messages:

WARNING MESSAGES (accompanied by warning light and siren)		
>CONFIG FLAPS		takeoff roll is started AND flaps are not in takeoff position
>CONFIG GEAR		landing conditions are detected AND gear is not down and locked
>CONFIG GEAR CTR		takeoff roll is started AND any body gear steering is not centered
>CONFIG PARK BRK		takeoff roll is started AND parking brake is set
>CONFIG SPOILERS		takeoff roll is started AND speedbrake lever is not in down detend
>CONFIG STAB		takeoff roll is started AND stabilizer trim is not within green band
>OVERSPEED		IAS or Mach exceeds maximum operating limit

ADVISORY MESSAGES		
>ALT CALLOUT		automatic EGPWS altitude call-outs are inoperative
>CONFIG WARN SYS		takeoff and landing configuration warning system is inoperative
>GND PROX SYS		EGPWS fault OR no input from radio altimeters
MAWEA INPUT		manual fire test attempted AND no fire detection input to MAWEA
>TCAS OFF		TCAS is off *[message inhibited by >TCAS SYSTEM]*
>TCAS RA ()		onside PFD (CAPT or F/O) cannot display TCAS resolution advisories
>TCAS SYSTEM		both PFDs and NDs cannot display TCAS resolution advisories
>WINDSHEAR SYS		reactive EGPWS windshear alert system has failed

EICAS Messages:

STATUS MESSAGES		
AURAL WARN SPKR		left or right aural warning speaker is inoperative
CONFIG WARN SYS		takeoff and landing configuration warning system is inoperative
EICAS DSP		switch fault on EICAS display select panel
GND PROX SYS		EGPWS fault OR no input from radio altimeters
MAWEA ID CARD		MAWEA tail identification card fault
MAWEA MASTER MON		MAWEA master monitor card A or B is inoperative
MAWEA PWR SUPPLY		MAWEA power supply A or B is inoperative
MAWEA SCID CARD		MAWEA signal collection card fault
STALL WARN SYS		stall warning system is inoperative
TCAS SYSTEM		TCAS has failed
TERR SYS		EGPWS terrain display is inoperative
WINDSHEAR PRED		predictive windshear alert system has failed
WINDSHEAR REAC		reactive EGPWS windshear alert system has failed

Limitations in the Simulator:

The status message AURAL SYNTH CARD is not included as this fault is not modeled.

Limitations

Weight limitations

On *non-ER* variants, the maximum takeoff weight is aircraft specific and ranges from:
362870 kg (800000 lb) to 396890 kg (875000 lb)
On *ER* variants, the maximum takeoff weight is:
412760 kg (910000 lb)
The maximum landing weight is aircraft specific and ranges from:
260360 kg (574000 lb) to 295740 kg (652000 lb) on *non-ER* variants
263530 kg (581000 lb) to 295740 kg (652000 lb) on *ER* variants

Maximum altitudes

Clean:	45100 ft
Flaps extended:	20000 ft
APU:	20000 ft
APU bleed air:	15000 ft
Takeoff and landing:	10000 ft

Cabin pressurization

Maximum differential:	9.40 psi
Maximum differential, takeoff and landing:	0.11 psi

Maximum airspeed in turbulent air

290 to 310 KIAS, Mach 0.82 to 0.85

Wind limits

Maximum headwind, autoland:	25 kt
Maximum tailwind, autoland:	10 kt
Maximum crosswind, autoland, all engines:	25 kt
Maximum crosswind, autoland, one engine out:	5 kt
Maximum crosswind, takeoff, manual landing:	30 kt
Parked with side or lower cargo door in transit:	40 kt
Parked with side or lower cargo door open:	65 kt

Maximum tire speed

204 kt (groundspeed or wheel speed)

Tire pressure

Nose wheel:	195 to 205 psi
Main wheels, *non-ER* variants:	205 to 215 psi
Main wheels, *ER* variants:	226 to 230 psi

Approved low visibility approach & landing operations

CAT I – decision height 200 ft or above:
- Manual approach, with or without flight director.
- Single, dual, or triple channel approach with manual landing.
- Dual or triple channel approach and landing.

CAT II – decision height 100 to 200 ft, RVR 350 m (1150 ft):
- Dual or triple channel approach with manual landing.
- Dual or triple channel approach and landing.

CAT III**a** – decision height 50 to 100 ft, RVR 200 m (650 ft):
- Dual or triple channel approach and landing.

CAT III**a** *all engines* – decision height 17 to 100 ft, RVR 200 m (650 ft):
- Triple channel approach and landing.

CAT III**a** *one engine out* – decision height 23 to 100 ft, RVR 200 m (650 ft):
- Triple channel approach and landing.

CAT III**b** *all engines* – decision height 17 to 50 ft, RVR 125 m (400 ft):
- Triple channel approach and landing.

CAT III**b** *one engine out* – decision height 23 to 50 ft, RVR 125 m (400 ft):
- Triple channel approach and landing.

Triple channel: Three autopilots engaged (LAND 3)
Dual channel: Two autopilots engaged (LAND 2)
Single channel: One autopilot engaged (NO AUTOLAND)

Autoland limitations

Maximum glideslope angle:	3.25°
Minimum glideslope angle:	2.50°
Required flap setting:	25 or 30

Runway slope limits

Maximum +/- 2%

Load acceleration limits

Flaps up:	+2.5 g to -1.0 g
Flaps extended:	+2.0 g to 0.0 g

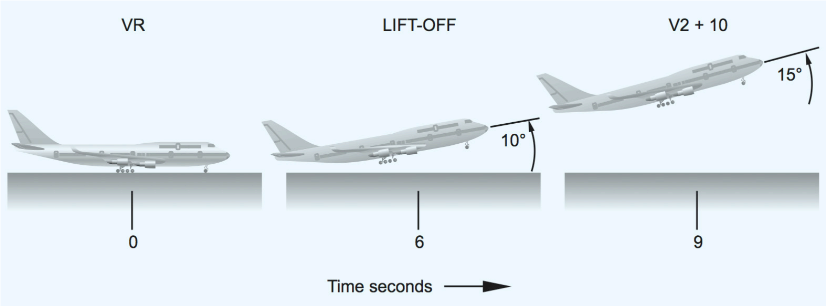
Procedures

Taxi:

When starting taxi, do not apply more than circa 40% N1. It will take some seconds until the aircraft has accelerated to taxi speed. The acceleration time is greater at higher gross weights, or when on upslopes. Under most conditions, when the aircraft has reached the desired taxi speed, idle thrust is sufficient to maintain the speed.

Takeoff:

At VR, rotate smoothly and continuously at a rate of 2.0° to 2.5° per second to the target body attitude which is typically in the range of 15° to 18°. The aircraft will lift off prior to reaching the initial 8° pitch indicated by the flight director. After reaching the target body attitude, and when a short time delay has passed, the flight director will provide elevator commands to maintain a target airspeed instead of a target body attitude. If the rotation rate was correct, the target body attitude will result in an airspeed of approximately V2+10.



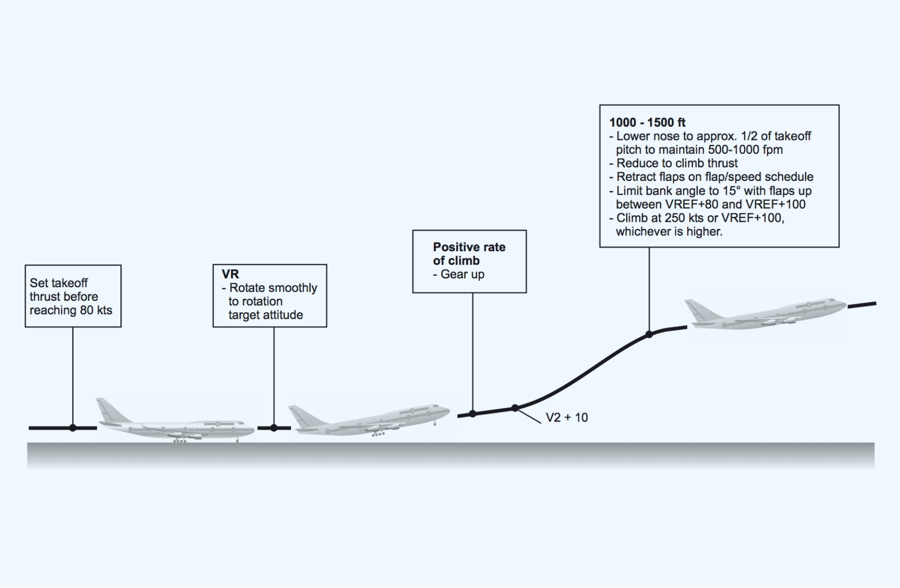
Manual Descent:

The airspeed displayed on the FMC descent page should be used as a target speed for the descent. When the top of descent is reached, descend at idle thrust in clean configuration—and, if possible, without extending the speedbrakes. The approximate target altitude is 10000 ft above the runway at 30 nm from the destination.

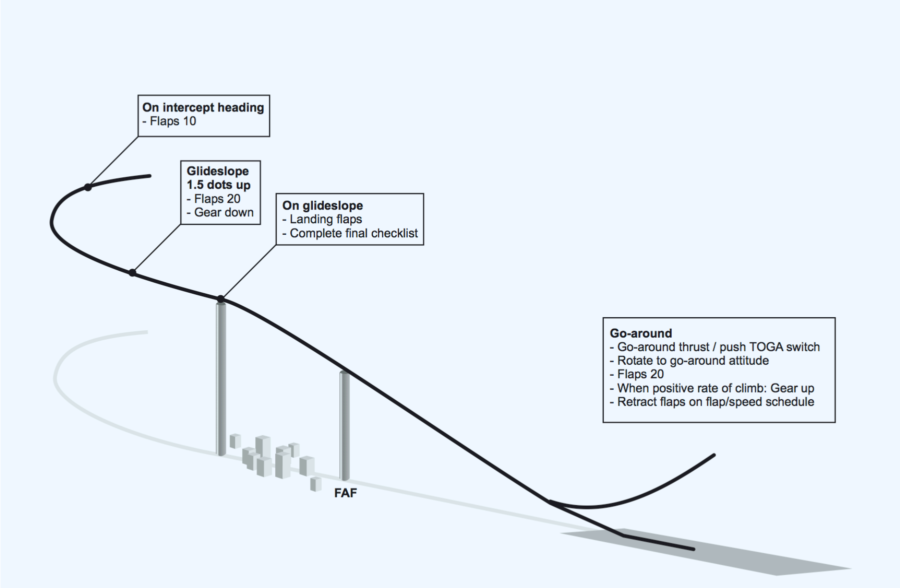
Manual Flare and Touchdown:

When the landing flaps are set, the recommended target speed is VREF+5, plus wind corrections if required. At 30 ft RA initiate the flare by increasing the pitch by circa 2° while smoothly moving the thrust levers to idle. Then keep the pitch attitude constant until touchdown. Do not allow the aircraft to float; fly the aircraft onto the runway. In case of a crosswind landing on a wet or icy runway, it is not necessary to eliminate the crosswind crab angle prior to touchdown.

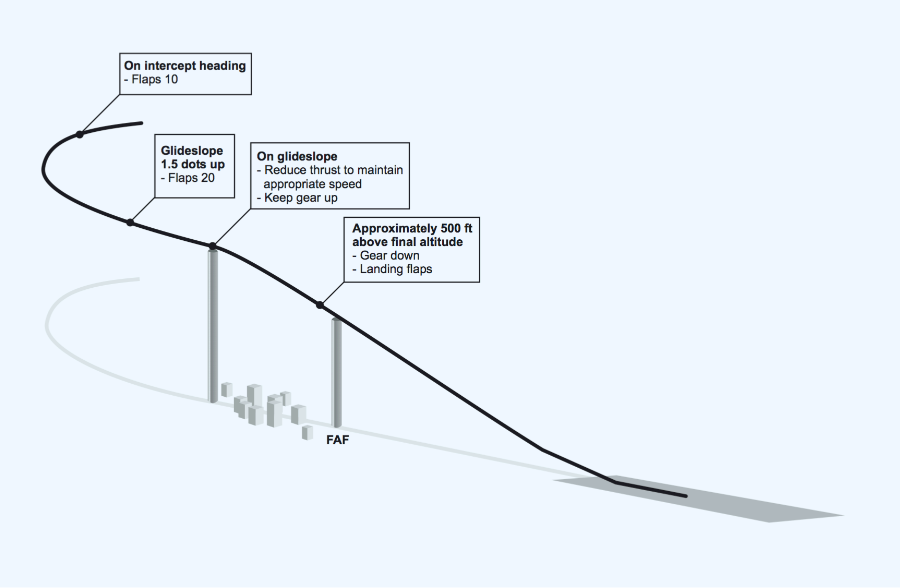
Manual Takeoff:



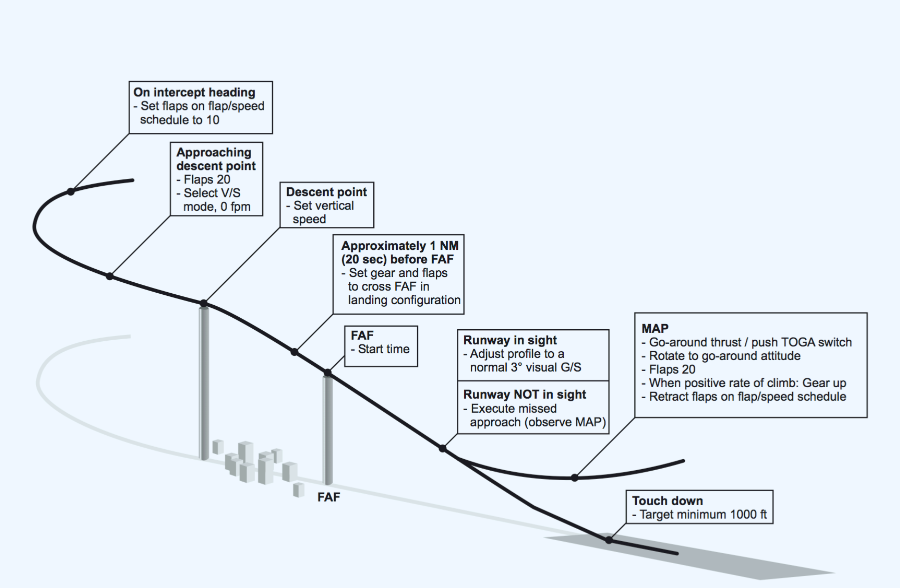
Manual ILS Approach:



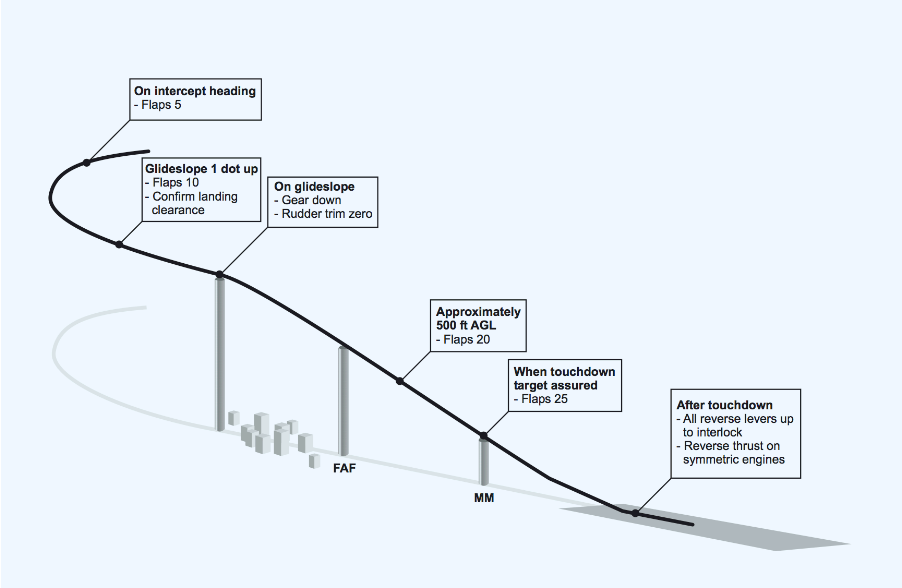
ILS Noise Abatement:



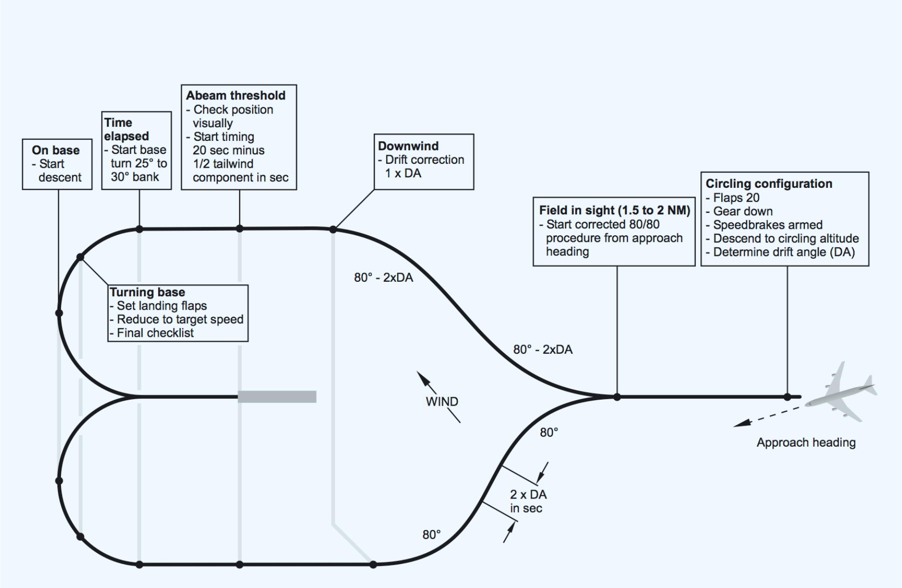
Manual Non-Precision Approach:



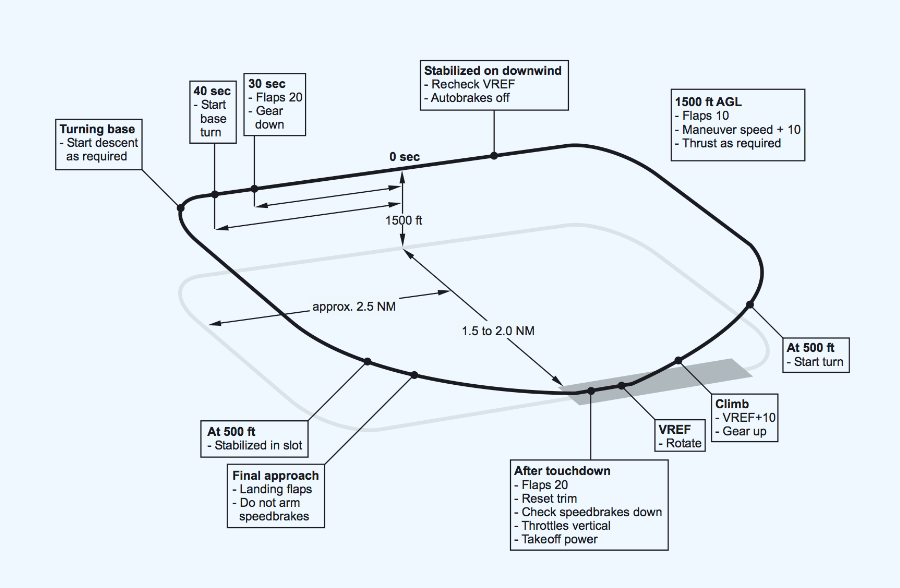
Two Engines Inoperative Landing:



Circling Approach:



Training Pattern (Touch and Go):



Normal Procedures (Examples):

Procedures vary slightly from airline to airline. The procedures described in this chapter are examples only.

Abbreviations:

1	left seat
2	right seat
pf	pilot flying
nf	pilot non-flying
b	both pilots.

(In the simulator, magenta items may be disregarded.)

Captain – Exterior Safety Inspection:

Wheel chocks .... IN PLACE
Gear doors .... CHECK
Flight control surface areas .... CLEAR

First Officer – Cockpit Safety Inspection:

Battery switch .... ON
Standby power selector .... AUTO
Hydraulic demand pump selectors ..... OFF
Alternate flap selector .... OFF
Gear lever .... DN
Flap position indication and lever .... AGREE

Confirm OFF light is extinguished.
Confirm upper EICAS display is shown.

Captain or Competent Crew Member – Exterior Inspection:

Obvious wear and damage .... CHECK

Preliminary Cockpit Preparation:

Maintenance status	CHECK	*b*	Check logbook and MEL requirements.
Electrical power	ESTABLISH	*2*	Check bus tie switches are set to AUTO. If external power is required, push respective EXT PWR switch and check ON light is illuminated. If APU power is required, start the APU, wait 30 seconds, then push APU GEN 1 switch, then APU GEN 2 switch; check ON lights are illuminated.
Ground interphone	SET	*2*	Confirm FLT is selected on ACP and speaker volume is turned up.
Ground test switch	CLOSED	*2*	
Flight control shutoff switches	CLOSED	*2*	
Refueling switches	CLOSED	*2*	
Generator field reset switches	CLOSED	*2*	
Split system breaker switch	CLOSED	*2*	
Towing power switch	OFF	*2*	
Cargo air flow rate selector	AS REQUIRED	*2*	
Voice recorder	TEST	*2*	Push and hold the test switch for 7 seconds and check the needle stays within the green band.
IRS on battery light	EXTINGUISHED	*2*	
EEC maintenance switches	CLOSED	*2*	
Defueling switches	CLOSED	*2*	
Circuit breakers P7	CHECK	*2*	
Emergency equipment	CHECK	*2*	
Ship's papers	CHECK	*2*	
Circuit breakers P6	CHECK	*2*	

First Officer – Cockpit Preparation:

ELT switch	ARMED	Check the guard is closed.
EEC mode switches	NORM	
IRS mode selectors	OFF TO NAV	Do not cycle through ATT position.
Utility power switches	ON	
Generator control switches	ON	
Demand pump selectors	OFF	
Engine pump switches	ON	
Fire/overheat test	PERFORM	Push and hold the test switch. Check the fire bell sounds and visual fire warnings appear. Release the test switch when the FIRE TEST PASS message is displayed.
Emergency light switch	ARMED	
Captain audio switch	NORM	
Observer audio switch	NORM	
Service interphone switch	OFF	
Fuel transfer 1 & 4 switch	OFF	
Engine fire switches	IN	
Bottle A/B discharge lights	EXTINGUISHED	
APU fire switch	IN	
APU bottle discharge light	EXTINGUISHED	
Cargo discharge light	EXTINGUISHED	
Cargo fire arm switches	OFF	
Engine start switches	IN	
Standby ignition selector	NORM	
Continuous ignition switch	OFF	
Auto ignition selector	SINGLE	
Autostart switch	ON	
Jettison control selector	OFF	
Jettison nozzle switches	OFF	

(continued next page)

First Officer – Cockpit Preparation: *(continued)*

Fuel pump switches	OFF	Set all fuel pump switches to OFF.
Nacelle anti-ice switches	AUTO	
Wing anti-ice switch	AUTO	
Window heat switches	ON	
Passenger oxygen switch	CLOSED	
Yaw damper switches	ON	INOP illuminates until IRS is aligned.
Outflow valve indicators	OPEN	
Manual outflow switches	OFF	
Auto select switch	NORM	
Passenger temp selector	AUTO	
Flight deck temp selector	AUTO	
Cargo temp selector	AUTO	
Zone system fault light	EXTINGUISHED	
Trim air switch	ON	
Recirculation fan switches	ON	
Aft cargo heat switch	OFF	
Equipment cooling selector	NORM	
High flow switch	OFF	
Pack system fault light	EXTINGUISHED	
Pack control selectors	NORM	
Isolation valve switches	ON	
Bleed system fault lights	EXTINGUISHED	
APU bleed air switch	ON	
Engine bleed air switches	ON	
Exterior lights	AS REQUIRED	
Flight director switch L	ON	
Autothrottle arm switch	OFF	
Bank limit selector	AUTO	
Heading	SET	Set runway heading if known.
Altitude	SET	Set initial SID constraint if known.
A/P disengage bar	UP	
Flight director switch R	ON	

(continued next page)

First Officer – Cockpit Preparation: *(continued)*

EFIS control panel R .... SET	Remove minimums, and set QNH.
Sidewall R .... CHECK	
Source selectors R ....VERTICAL	Set FCC, NAV, EIU, IRS, ADC sources.
Clock R .... CHECK	If required, set time and calendar date.
Inboard CRT selector R .... NORM	
Outboard CRT selector R ....NORM	
PFD .... .CHECK	When IRS aligned, check flags removed. (NO V SPD flag remains until V-speeds entered.) Check FMA: A/T mode blank, roll mode TO/GA, pitch mode TO/GA. Heading reference MAG, altimeter at field elevation.
ND .... .CHECK	When IRS aligned, check flags removed. Cross-check with standby compass.
Ground proximity light....EXTINGUISHED	
Flap alert override switch ....OFF	
Gear alert override switch ....OFF	
Terrain alert override switch ....OFF	
FMC IDENT page ....CHECK	Models, dates, drag/fuel flow factors.
FMC POS INIT page ....SET	IRS position, UTC.
FMC RTE 1 page ....SET	Route, flight number.
FMC DEPARTURES page ....SET	Runway, SID, transition.
FMC ARRIVALS page ....SET	Approach, STAR, transition.
FMC RTE 1 page ....ACTIVATE, EXEC	
FMC PERF INIT page................SET	Reserves, cost index, cruise altitude.
ACARS initial request .... INITIATE	
Radio tuning panel R .... SET	
Audio control panel R ....SET	
FMC THRUST LIM page ....SET	
FMC TAKEOFF REF page ....SET	
FMC NAV RADIO page ....SET	
FMC RTE 1 LEGS pages ....CHECK	SID waypoints, courses, constraints.
FMC RTE 1 DATA pages ....SET	
FMC VNAV CLB page .... CHECK	Transition altitude.

Captain – Cockpit Preparation:

EFIS control panel L	SET	Remove minimums, and set QNH.
Sidewall L	CHECK	
Source selectors L	VERTICAL	Set FCC, NAV, EIU, IRS, ADC sources.
Clock L	CHECK	If required, set time and calendar date.
Inboard CRT selector L	NORM	
Outboard CRT selector L	NORM	
PFD L	CHECK	When IRS aligned, check flags removed.
ND L	CHECK	When IRS aligned, check flags removed.
Standby attitude indicator	CHECK	Pull and hold cage knob for 3 seconds.
Standby airspeed indicator	CHECK	
Standby altimeter	CHECK	Set standard pressure 29.92 inches.
EICAS EIU source selector	AUTO	
Heading reference switch	NORM	
FMC master switch	L	
Status display switch	PUSH	
Status display	CHECK	Check no RF flag is shown on hydraulic quantity, check oxygen is sufficient, check status messages for MEL items.
Alternate flap arm switch	OFF	
Alternate gear switches	OFF	

(continued next page)

Captain – Cockpit Preparation: *(continued)*

FMC IDENT page .... CHECK
FMC POS REF page .... CHECK
FMC RTE 1 pages .... CHECK
FMC RTE 1 LEGS pages .... CHECK
Speedbrake lever .... DOWN
Parking brake .... AS REQUIRED
Reverse thrust levers .... DOWN
Thrust levers .... IDLE
Fuel control switches............. CUTOFF
Stab trim cutout switches .... CLOSED
Stab indicator OFF flag ......NOT IN VIEW
Radio tuning panel L .... SET
Audio control panel L .... SET
No smoking selector .... ON
Seatbelts selector .... ON
Weather radar panel .... AS REQUIRED
CDU C .... AS REQUIRED
Transponder panel .... SET
Autobrakes selector .... RTO

Final Cockpit Preparation:

Status messages	REVIEW	*b*	
Fuel quantity	CHECK	*b*	EICAS fuel indication should agree with ordered block fuel.
ACARS refueling report	PREPARE	*2*	
Fuel pump switches	AS REQUIRED	*2*	Refer to chapter **Fuel System**.
Fuel crossfeed switches	AS REQUIRED	*2*	Refer to chapter **Fuel System**.
Cockpit checklist	PERFORM	*b*	
Load sheet	CHECK, SIGN	*1*	
FMC PERF INIT page	CHECK	*b*	
FMC THRUST LIM page	CHECK	*b*	
FMC TAKEOFF REF page	CHECK	*b*	
MCP speed	V2	*1*	
MCP LNAV switch	PUSH	*1*	Check LNAV is armed on PFD.
MCP VNAV switch	PUSH	*1*	Check VNAV is armed on PFD.

Before Start:

All doors closed	CHECK	*1*	
Start clearance	RECEIVE	*1*	
Pushback	AS REQUIRED	*1*	During pushback, continue start preparation and start the engines.
Hydraulic demand pump 4	AUX	*1*	
Hydraulic demand pumps 1, 2, 3	AUTO	*1*	
Pack control selectors	AS REQUIRED	*1*	Pack 1 or pack 2 may be on. If possible, set all packs off for engine start.
Beacon	BOTH	*1*	
Parking brake	AS REQUIRED	*1*	Do not set parking brake during pushback.
Secondary engine display	SELECT	*2*	
Cancel switch	PUSH	*2*	Blank all caution and advisory messages.
Stabilizer trim	AS REQUIRED	*2*	
Aileron trim	ZERO	*2*	
Rudder trim	ZERO	*2*	
Before start checklist	PERFORM	*b*	

Automatic Engine Start:

"Engines 3 and 4 start!"	ANNOUNCE	*1*	
Fuel control switch 3	RUN	*1*	
Fuel control switch 4	RUN	*1*	
Engine start switch 3	PULL	*2*	
Engine start switch 4	PULL	*2*	
Engine indications	MONITOR	*b*	Check oil, EGT, N1 are rising normally.
"Engines 1 and 2 start!"	ANNOUNCE	*1*	When engines 3 & 4 stabilized at idle.
Fuel control switch 1	RUN	*1*	
Fuel control switch 2	RUN	*1*	
Engine start switch 1	PULL	*2*	
Engine start switch 2	PULL	*2*	
Engine indications	MONITOR	*b*	Check oil, EGT, N1 are rising normally.

After Start:

Ground crew clearance	REQUEST	*1*	
APU selector	OFF	*2*	
Hydraulic demand pump 4	AUTO	*2*	
Nacelle anti-ice switches	AS REQUIRED	*2*	Set ON if icing conditions, else AUTO.
Aft cargo heat	AS REQUIRED	*2*	
Cargo air flow rate selector	AS REQUIRED	*2*	
Pack control selectors	NORM	*2*	Set to NORM for taxi.
Engine oil quantity	CHECK	*2*	
Recall switch	PUSH	*2*	Review known messages.
Cancel switch	PUSH	*2*	Not required when no messages shown.
Taxi clearance	RECEIVE	*b*	
After start checklist	PERFORM	*1*	

Taxi:

Ground crew clearance	RECEIVE	*1*	
Taxi area clear	CONFIRM	*b*	
Parking brake	RELEASE	*1*	
Taxi	PERFORM	*1*	
ACARS off block time	CHECK	*2*	
Flaps	SET	*2*	Set takeoff flap setting.
Status display switch	PUSH	*2*	F/O monitors EICAS flight controls:
Control wheel	FULL LEFT	*2*	Left wing: Spoiler & two ailerons up. Right wing: Two ailerons down.
Control wheel	FULL RIGHT	*2*	Right wing: Spoiler & two ailerons up. Left wing: Two ailerons down.
Control wheel	CENTER	*2*	Spoilers down, ailerons centered.
Control column	FULL AFT	*2*	Two elevators full up.
Control column	FULL FORWARD	*2*	Two elevators full down.
Control column	CENTER	*2*	Two elevators centered.
"Rudder!"	ANNOUNCE	*1*	
Tiller	HOLD	*1*	F/O monitors EICAS flight controls:
Rudder pedals	FULL LEFT	*1*	Two rudders full left.
Rudder pedals	FULL RIGHT	*1*	Two rudders full right.
Rudder pedals	CENTER	*1*	Two rudders centered.
Status display switch	PUSH	*2*	Blank secondary EICAS display.
FMC pages	SELECT	*b*	PF uses VNAV page, PNF uses LEGS.
Cabin report	RECEIVE	*1*	
Taxi checklist	PERFORM	*b*	
Takeoff briefing	PERFORM	*pf*	
RTO briefing	PERFORM	*1*	

Takeoff:

Pack control selectors .... OFF	*2*	If performance margin is sufficient, pack 2 selector may be set to NORM.
Strobe lights switch .... ON	*2*	Set to ON when entering the runway.
Landing light switches .... ON	*1*	Set all ON when entering the runway.
Autothrottle arm switch .... ARM	*2*	
TCAS control selector .... RA/TA	*2*	
TCAS above-below selector .... A	*2*	Select above-mode.
Takeoff data .... VERIFY	*b*	Confirm performance settings are in accordance with ambient conditions.
Takeoff checklist .... PERFORM	*b*	
Control transfer .... ANNOUNCE	*b*	If the F/O is the designated PF, the captain announces, *"You have control!"*; and the F/O verifies, *"I have control!"*
"Takeoff!" .... ANNOUNCE	*1*	
Brakes .... RELEASE	*1*	
Clocks L & R chronograph .... START	*b*	
Clocks L & R elapsed time .... START	*b*	
Directional control .... MAINTAIN	*pf*	Push control column slightly forward and turn ailerons into crosswind; use rudder pedals to maintain centerline.
Thrust levers .... VERTICAL	*1*	Advance to circa 70% N1.
TO/GA switch .... PUSH	*1*	Check autothrottle advances to takeoff power setting. Keep hand on thrust levers until reaching V1 minus 3.
PFDs .... CHECK	*b*	Check THR REF is engaged.
NDs .... CHECK	*b*	Check aircraft symbol on runway.
Engine indications .... MONITOR	*nf*	Observe N1 and EGT.
"Takeoff power set!" .... ANNOUNCE	*nf*	When takeoff power is stabilized.
"Eighty!" .... ANNOUNCE	*nf*	At 80 kt cross-check airspeed indicators; if they agree, PF confirms, "Checked!"
"Go!" .... ANNOUNCE	*nf*	When reaching V1 minus 3.
"Rotate!" .... ANNOUNCE	*nf*	When reaching VR.
Rotation .... PERFORM	*pf*	

(continued next page)

Takeoff: *(continued)*

Gear .... RETRACT	*nf*	When commanded by PF.
Autopilot .... AS REQUIRED	*pf*	Engage when desired, but not below 250 ft RA. If captain is PF, use CMD L on even flight numbers, CMD C on odd numbers. If F/O is PF, use CMD R.
Climb power .... CHECK	*nf*	At thrust reduction point, check that thrust changes to selected climb limit.
Gear lever .... OFF	*nf*	When gear is up and climb power is set.
Pack control selectors .... NORM	*nf*	Set all selectors to NORM.
Flaps .... RETRACT	*nf*	According to flap speed schedule.
Anti-ice switches .... AUTO	*nf*	If switches have been set to ON before.

Climb & Cruise:

Altimeters .... SET & CHECK	*b*	When passing transition altitude.
Landing light switches .... OFF	*nf*	When passing 10000 ft.
Logo lights switch .... OFF	*nf*	When passing 10000 ft.
Navaids .... DELETE	*nf*	When requested by PF, delete manually tuned stations.
Seatbelt signs .... AUTO	*nf*	
Cruise data .... ENTER	*nf*	
Aircraft trim .... CHECK	*pf*	When cruise thrust is set.
Fuel management .... OBSERVE	*nf*	Refer to chapter **Fuel System**.

Descent & Approach:

Landing information	RECEIVE	*nf*	
FMC approach data	PREPARE	*nf*	Enter route and VNAV data as per ATC clearance.
Landing weight	REVIEW	*b*	
Landing distance	DETERMINE	*b*	
Landing flap setting	DETERMINE	*b*	
Autobrakes	DETERMINE	*b*	
Descent briefing	PERFORM	*pf*	
Seatbelt signs	ON	*nf*	
Recall switch	PUSH	*nf*	Review messages and consequences.
Cancel switch	PUSH	*nf*	Not required if no messages shown.
Landing altitude	CHECK	*nf*	Select ECS synoptic to show landing altitude on primary EICAS.
Altimeter preselection	PRESELECT	*b*	
Minimum	SET	*b*	For non-precision and CAT I approaches set baro minimum and blank radio minimum, else set radio minimum and blank baro minimum.
FMC approach data	SET	*nf*	Set VREF and required navaids. Check approach, missed approach, and VNAV transition level data.
TCAS above-below selector	B	*nf*	Set below-mode.
Autobrakes	SET	*nf*	
Approach briefing	PERFORM	*pf*	
Landing light switches	ON	*nf*	When passing 10000 ft.
Logo lights switch	AS REQUIRED	*nf*	When passing 10000 ft.
Altimeters	QNH	*b*	When reaching transition level, push STD switch to change to QNH.
Minimums	VERIFY	*b*	
FMC navigation accuracy	CHECK	*b*	If map shift exists, do not use LNAV.
Flaps	EXTEND	*nf*	According to flap speed schedule.
Cabin report	RECEIVE	*1*	
Approach checklist	PERFORM	*b*	

Final:

Gear	EXTEND	*nf*	When requested by PF.
Speedbrake lever	ARM	*1*	
Flaps	EXTEND	*nf*	PNF sets MCP speed for each flap setting.
Wind conditions	EVALUATE	*b*	
Altitude	CHECK	*b*	Set missed approach altitude on MCP.
Nacelle anti-ice	AS REQUIRED	*nf*	
Wind readout	OBSERVE	*nf*	Announce significant changes.
Final checklist	PERFORM	*b*	

Landing:

Thrust levers	IDLE	*pf*	
Reverser levers	PULL	*pf*	After main gear touchdown.
Speedbrakes	CHECK	*b*	Verify autodeployment.
"Eighty!"	ANNOUNCE	*nf*	When airspeed decreases below 80 kt.
Reverser levers	IDLE	*pf*	Set idle at 80 kt, stow at 60 kt.
Brake performance	MONITOR	*pf*	Observe autobrake operation.
Autopilots	DISENGAGE	*pf*	If autopilots have been engaged before.
Control transfer	ANNOUNCE	*b*	If the F/O was the PF, the captain announces, *"I have control!"*; and the F/O verifies, *"You have control!"*
Taxi	PERFORM	*1*	

After Landing:

Speedbrake lever	DOWN	*1*	
Landing light switches	AS REQUIRED	*1*	
Strobe lights switch	OFF	*2*	
Flaps	UP	*2*	
APU selector	START, ON	*2*	
Aft cargo heat	OFF	*2*	
Weather radar	OFF	*2*	Deselect WXR on both EFIS controls.
Flight director switches	BOTH OFF	*2*	
Stabilizer trim	6 UNITS	*2*	
Transponder control	STBY	*2*	
Autobrakes	OFF	*2*	
No. 3 fuel control switch	AS REQUIRED	*2*	May be set to CUTOFF for economic and environmental reasons if no upslope or icing is expected.

Parking:

Parking brake	SET	*1*	
APU generators	ON	*2*	
Fuel control switches	CUTOFF	*1*	
Hydraulic demand pumps	OFF	*2*	
Anti-ice	AUTO	*2*	
Seatbelt selector	OFF	*2*	
Fuel pump switches	OFF	*2*	
Packs	AS REQUIRED	*2*	
Beacon	OFF	*2*	
IRS error	CHECK	*2*	
IRS mode selectors	OFF	*2*	
Cargo air flow rate selector	OFF	*2*	
EICAS status display	CHECK	*b*	Note status messages.
External power	AS REQUIRED	*2*	
Emergency lights switch	OFF	*2*	
Parking checklist	PERFORM	*1*	

Leaving Aircraft:

APU & external power	OFF	*2*	
Standby power selector	OFF	*2*	
Battery switch	OFF	*2*	Leave the switch ON for 2 minutes after selecting APU to OFF; this provides fire detection during APU cooling phase.
Leaving airplane checklist	PERFORM	*1*	

Abnormal Lists

General:

Abnormal lists—sometimes referred to as *non-normal checklists*—describe actions the crew has to do when a failure exists or when a failure is expected; hence, the term "list" is sometimes used instead of the term "checklist"—the latter typically helps checking whether actions are already done.

Items marked with "PF" are performed by the pilot flying; items marked with "B" are performed by both pilots. All other items are performed by the pilot non-flying.

Most of the abnormal lists refer to EICAS alert messages, specifically to those not preceded by a caret ">". Certain details in the lists are airline and aircraft specific.

This chapter shows some examples of abnormal lists.

Air Systems:

CABIN ALTITUDE

Message: **CABIN ALTITUDE**

Isolation Valve Sws .... **BOTH OFF**
Cabin Altitude & Rate .... **CHECKED**

IF cabin altitude...

...out of control:

Passenger Oxygen Sw .... **ON**
Descent .... **INITIATE**

END.

...stabilized:

IF duct pressure...

...both remain normal:

Pack 2 Control Sel .... **OFF**

END.

...one remains low:

Engine Bleed Air Sws .... **AFFECTED SIDE OFF**
BLEED OFF messages are displayed
Isolation Valve Sw .... **NORMAL SIDE ON**
Pack Control Sel .... **AFFECTED SIDE OFF**
Hyd Demand Pump 1 or 4 .... **AFFECTED SIDE OFF**
HYD PRESS DEM message is displayed
Wing Anti-Ice Sw .... **OFF**

APPROACH REVIEW

- Allow enough time for secondary flap operation
- Maximum one pack on
- Extend or retract flaps as required

Air Systems:

EMERGENCY DESCENT

Passenger Oxygen	**ON**	**PF**
Descent	**INITIATED**	**PF**
Throttles	**IDLE**	**PF**
Speedbrakes	**FLIGHT DETEND**	**PF**
Target Speed	**MAINTAINED**	**PF**

CAUTION

If structural integrity is not assured, limit airspeed to present indicated airspeed and avoid high maneuvering loads. If gear is extended monitor limit speed.

Minimum Enroute Altitude .... **DETERMINED**

NOTE

Establish level flight at 15 000 ft or below. If MEA is higher than 15 000 ft establish level flight at MEA. Establish level flight within 10 minutes from the beginning of the decompression.
On critical routes, between 12 000 and 15 000 ft consider closing of all cabin oxygen outlets for 30 minutes.
Establish level flight at 12 000 ft or below within 30 minutes after passenger oxygen has been consumed.
Establish level flight at 8 000 ft or below when first aid oxygen has been consumed. Reset oxygen system before landing.

Oxygen Sel .... **NORMAL**
Cabin Signs .... **ON**

Air Systems:

BLEED DUCT LEAK

Message: **BLD DUCT LEAK L, C, R**

IF message...

...BLD DUCT LEAK C:

Isolation Valve Sws	**OFF**
Pack 2 Control Sel	**OFF**
APU Bleed Air Sw	**OFF**
Aft Cargo Heat Sw	**OFF**
Trim Air Sw	**OFF**

END.

...BLD DUCT LEAK L or R:

Isolation Valve Sw	**AFFECTED SIDE OFF**
Isolation Valve Sw	**UNAFFECTED SIDE ON**
Engine Bleed Air Sws	**AFFECTED SIDE OFF**
BLEED OFF messages are displayed	
Pack Control Sel	**AFFECTED SIDE OFF**
Hyd Demand Pump 1 or 4	**AFFECTED SIDE OFF**
HYD PRESS DEM message is displayed	
Wing anti-Ice Sw	**OFF**

APPROACH REVIEW

- Allow sufficient time for secondary flap operation
- Maximum one pack on
- Extend or retract flaps as required

Air Systems:

BLEED OVERHEAT

Message: **BLEED 1, 2, 3, 4 OVHT**

Engine Bleed Air Sw . . . . **OFF**

BLEED OFF message is displayed

NOTE
Nacelle anti-ice and reverse thrust is not available for affected engine

EQUIPMENT COOLING

Message: **EQUIP COOLING**

NOTE
Avionics, electronics and displays may become unreliable or fail.

IF...

...in flight:

Equipment Cooling Sel . . . . **OVRD**

...on ground:

Equipment Cooling Sel . . . . **STBY**

CAUTION
If message remains displayed land at next suitable airport

Air Systems:

LANDING ALTITUDE

Message: **LANDING ALT**

Landing Altitude Sw . . . . **SELECT MAN**
Landing Altitude Control . . . . **SET MANUALLY**

PACK

Message: **PACK 1, 2, 3**

Trim Air Sw . . . . **ON**
Pack Control Sel . . . . **AFFECTED PACK(S) A**
Pack Reset Sw . . . . **PUSH**

IF message...

- ...no longer displayed:
  END.
- ...remains displayed:
  Pack Control Sel . . . . **AFFECTED PACK(S) B**
  Pack Reset Sw . . . . **PUSH**
  - ...no longer displayed:
    END.
  - ...remains displayed or is displayed again:
    Pack Control Sel . . . . **AFFECTED PACK(S) OFF**

NOTE

Allow 5 minutes for cooling prior to attempting an additional reset using controller B, then A.

Air Systems:

SMOKE AIR CONDITIONING

Recirculation Fan Sws . . . . **OFF**
APU Sel . . . . **OFF**

IF smoke...

...decreases:
END.

...continues:

Isolation Valve Sws . . . . **BOTH OFF**

IF smoke...

...decreases:
END.

...continues:

Pack 3 Control Sel . . . . **OFF**

IF smoke...

...decreases:
Isolation Valve Sws . . . . **UNAFFECTED SIDE ON**
END.

...continues:

Pack 3 Control Sel . . . . **NORM**
Pack 1 Control Sel . . . . **OFF**
Isolation Valve Sw . . . . **UNAFFECTED SIDE ON**

Air Systems:

WING ANTI-ICE VALVE

Message: **WAI VALVE LEFT, RIGHT**

IF Wing Anti-Ice Sw is...

...ON:

Wing Anti-Ice Sw . . . . **OFF**

END.

...OFF:

Wing Anti-Ice Sw . . . . **ON**

AFTER LANDING
- Engine Bleed Air Sws affected side OFF.
- Isolation Valve Sws affected side OFF.

END.

...AUTO:

Wing Anti-Ice Sw . . . . **ON**

IF WAI VALVE message...

...remains displayed:

Wing Anti-Ice Sw . . . . **OFF**

END.

...no longer displayed:

AFTER LANDING REVIEW
- Engine Bleed Air Sws affected side OFF.
- Isolation Valve Sws affected side OFF.

APU:

FIRE APU

Message: **FIRE APU**

APU Fire Sw .... **PULLED AND ROTATED**

APU message is displayed if APU selector is on

APU

Message: **APU**

IF APU selector...

...ON:

APU Sel .... **OFF**

NOTE

If message no longer displayed restart may be attempted

END.

...OFF:

APU Fire Sw .... **PULL**

Electrical:

ELECTRICAL AC BUS

Message: **ELEC AC BUS 1, 2, 3, 4**

Generator Control Sw . . . . **OFF, THEN ON**

> NOTE
> Attempt only one reset of generator control breaker

IF message ELEC AC BUS...

...remains displayed:

> NOTE
> Do not attempt to close the bus tie breaker

END.

...no longer displayed:

ELEC BUS ISLN message is displayed

Bus Tie Sw . . . . **OFF, THEN AUTO**

> NOTE
> Attempt only one reset of bus tie breaker

ELECTRICAL BUS ISOLATION

Message: **ELEC BUS ISLN 1, 2, 3, 4**

Bus Tie Sw . . . . **OFF, THEN AUTO**

> NOTE
> Attempt only one reset of bus tie breaker

Electrical:

ELECTRICAL DRIVE

Message: **ELEC DRIVE 1, 2, 3, 4**

Generator Drive Disconnect . . . . **PUSH**

DRIVE DISC message is displayed.

ELEC GEN OFF message is displayed.

ELECTRICAL GENERATOR OFF

Message: **ELEC GEN OFF 1, 2, 3, 4**

Generator Control Sw . . . . **OFF, THEN ON**

NOTE

Attempt only one reset of generator control breaker

ELECTRICAL UTILITY BUS

Message: **ELEC UTIL BUS L, R**

Utility Power Sw . . . . **OFF, THEN ON**

NOTE

Attempt only one reset of utility power

Engines:

FIRE ENGINE OR DAMAGE	
Message: **FIRE ENG 1, 2, 3, 4**	
Throttle	**NO.__ IDLE**
Fuel Control Sw	**NO.__ CUTOFF**
Engine Fire Sw	**NO.__ PULLED**
IF message FIRE ENG remains displayed:	
Engine Fire Sw	**NO.__ ROTATED**
IF message FIRE ENG remains displayed after 30 seconds:	
Eng Fire Sw	**NO.__ ROTATED TO OTHER BOTTLE**

MULTIPLE ENGINE FLAMEOUT OR STALL	
Fuel Control Sws	**AFFECTED ENGINES CUTOFF**
Fuel Control Sws	**AFFECTED ENGINES RUN**
IF airspeed is less than 220 kts:	
Engine Start Sws	**AFFECTED ENGINES PULL**
IF autostart is off:	
EGT	**(during start) MONITOR**

Engines:

VOLCANIC ASH

180° Turn	EXECUTE	PF
250-300 KIAS	MAINTAIN	PF
Autothrottle	DISCONNECT	PF
Throttles	IDLE	PF
Continuous Ignition Sw	ON	
Nacelle Anti-Ice Sws	ON	
Wing Anti-Ice Sw	ON	
Pack Control Sels	NORM	
High Flow Sw	ON	
Airspeed Indications	X-CHECK/MONITOR	
Engine Parameters	MONITOR	

CAUTION

If EGT limit is exceeded, shut down affected engine. Restart when clear of contaminated area. In case an engine fails to start, repeated attempts should be made.

Suitable Airport	SELECT

ENGINE FAILURE / SHUTDOWN

Throttle	NO.___ IDLE

NOTE

If condition permits, keep affected engine running at idle for two minutes for cooling and stabilizing.

Fuel Control Sw	NO.___ CUTOFF

Engines:

ENGINE INFLIGHT START

IF "X-BLD"...

...not displayed:

Fuel Control Sw . . . . **NO.__ RUN**

END.

...displayed:

Engine Start Sw . . . . **NO.__ PULL**

IF Autostart Sw is...

...ON:

Fuel Control Sw . . . . **NO.__ RUN**

END.

...OFF and N2 rises to Fuel-On-Command-Line:

Fuel Control Sw . . . . **NO.__ RUN**

Monitor EGT during engine start

ENGINE OIL PRESSURE

Message: **ENG 1, 2, 3, 4 OIL PRESS**

Oil Pressure Indication . . . . **CHECK**

If oil pressure at or below red line limit:

Throttle . . . . **NO.__ IDLE**
Fuel Control Sw . . . . **NO.__ CUTOFF**

Engines:

ENGINE OIL TEMPERATURE

Message: **ENG 1, 2, 3, 4 OIL TEMP**

Throttle .... **NO.__ RETARD**

If oil pressure at or below red line limit:

Throttle .... **NO.__ IDLE**
Fuel Control Sw .... **NO.__ CUTOFF**

OVERHEAT ENGINE NACELLE

Message: **OVHT ENG 1, 2, 3, 4 NAC**

Engine Bleed Air Sw .... **NO.__ OFF**
BLEED OFF message is displayed
Throttle .... **NO.__ RETARD**

IF message OVHT ENG NAC remains displayed:

Throttle .... **NO.__ IDLE**
Fuel Control Sw .... **NO.__ CUTOFF**

TWO ENGINES INOPERATIVE

Before approach:

Pack Control Sels .... **TWO PACKS OFF**
Ground Proximity Flap Override Sw .... **OVRD**
Next Suitable Airport .... **SELECT**

APPROACH REVIEW

- Use flaps 25 and VREF25 for landing
- Use flaps 1 for go-around
- Commit point is gear extent
- Fly final approach with flaps 10 and gear down
- Set flaps 20 at 500 ft
- Set flaps 25 when touchdown target is assured

Flight Controls:

FLAPS CONTROL

Message: **FLAPS CONTROL**

- In case of an EICAS interface failure the flaps will move normally
- While flaps are between UP and 5, limit airspeed to flap 5 placard speed.

Alternate Flaps Arm Sw . . . . **ALTN**
Alternate Flaps Sel . . . . **AS REQUIRED**

- Plan additional time for flap operation
- For landing use flaps 25 and VREF25

FLAPS DRIVE

Message: **FLAPS DRIVE**

Ground Proximity/Flap Override Sw . . . . **OVRD**

- Do not use alternate flaps
- For landing use flaps 25 and VREF25

FLAPS PRIMARY

Message: **FLAPS PRIMARY**

- Plan additional time for flap operation
- Monitor the secondary flap extent airspeed of 160 KIAS from flap 25 to 30

Flight Controls:

AILERON LOCKOUT

Message: **AILERON LOCKOUT**

- Avoid large or abrupt control wheel inputs at high airspeed
- Crosswind limit for landing is 20 kts

SPEEDBRAKE AUTOMATIC

Message: **SPEEDBRAKE AUTO**

- Do not arm speedbrake lever
- After touchdown extend ground spoilers manually

Fuel:

FUEL JETTISON

Do not jettison with flaps in transit between 1 and 5

Fuel Jettison Control Sel .... **A or B**
Fuel To Remain .... **SET**
Fuel Jettison Nozzle Valve Sws .... **BOTH ON**
Override Pump 2 and 3 Sws .... **ON**
FUEL OVRD message may be displayed

When jettison is completed:
Fuel Jettison Nozzle Valve Sws .... **BOTH OFF**
Fuel Jettison Control Sel .... **OFF**

FUEL PRESSURE ENGINE

Message: **FUEL PRESS ENG 1, 2, 3, 4**

Crossfeed Valve Sws .... **ALL ON**
Main Pump Sws .... **RESPECTIVE TANK ON**

If both main pumps in tank 1 or 4 are...

...operative:
END.

...inoperative:

Approximately 7000 lbs/3200 kgs of fuel in the affected tank is available only by suction feed

Override Pump 2 and 3 Sws .... **ON**

When message FUEL TANK/ENG is displayed:
Fuel Transfer Main 1+4 Sw .... **ON**
FUEL XFER 1+4 message is displayed

When message FUEL OVRD 2, 3, AFT and FWD is displayed:
Override Pump 2 and 3 Sws .... **OFF**
Crossfeed Valve 1 and 4 Sws .... **OFF**
FUEL PRESS ENG ( ) message is displayed

Fuel:

FUEL QUANTITY LOW

Message: **FUEL QTY LOW**

Crossfeed Valve Sws . . . . **ALL ON**
Main Pump Sws . . . . **ALL ON**

Avoid high nose up attitude and excessive acceleration

FUEL LEAK ENGINE

FMC message: **FUEL DISAGREE - PROG 2/2**

EICAS messages: **FUEL IMBALANCE** or **FUEL IMBAL 1-4, 2-3**

If an inflight engine fuel leak is suspected or confirmed:

FMC page PROG 2/2 . . . . **SELECT**
Totalizer and Calculated Quantity . . . . **COMPARE**

If engine fuel leak is suspected:

Stabilizer Tank Pump Sws . . . . **OFF**
Center Tank Pump Sws . . . . **OFF**
Crossfeed Valve Sws . . . . **NO. 1, 2, 3 and 4 OFF**
X FEED CONFIG message is displayed
Override Pump 2 and 3 Sws . . . . **OFF**
Fuel Distribution . . . . **OBSERVE EACH TANK**

Main fuel tank quantity for affected engine decreases faster than other tank quantities. If conditions permit, a crew member should visually check engines for a fuel leak.

If engine fuel leak is confirmed:

Throttle . . . . **AFFECTED ENGINE IDLE**

If condition permits, keep affected engine running at idle for two minutes for cooling and stabilizing.

Fuel Control Sw . . . . **AFFECTED ENGINE CUTOFF**

Use TOTALIZER to determine fuel remaining. After engine shutdown all remaining fuel may be used for the operating engines. Resume normal fuel management procedures.

Hydraulics:

HYDRAULIC OVERHEAT SYSTEM

Message: **HYD OVHT SYS 1, 2, 3, 4**

Disengage operating autopilot of affected system prior to depressurizing hydraulic system: Hyd 1 = A/P C, Hyd 2 = A/P R, Hyd 3 = A/P L.

Engine Pump Sw . . . . **AFFECTED SYSTEM OFF**
Demand Pump Sw . . . . **AFFECTED SYSTEM OFF**
HYD PRESS SYS message is displayed

IF message HYD OVHT SYS...

...remains displayed:
Perform HYDRAULIC PRESSURE SYSTEM procedure
END.

...no longer displayed:

Demand Pump Sel . . . . **AFFECTED SYSTEM AUTO**
HYD PRESS ENG message is displayed

IF message HYD OVHT SYS is displayed again:

Demand Pump Sel . . . . **AFFECTED SYSTEM OFF**
HYD PRESS SYS message is displayed

Perform HYDRAULIC PRESSURE SYSTEM procedure

HYDRAULIC PRESSURE DEMAND

Message: **HYD PRESS DEM 1, 2, 3, 4**

Demand Pump Sel . . . . **AFFECTED SYSTEM ON**

IF message HYD PRESS DEM remains displayed:

Demand Pump Sel . . . . **AFFECTED SYSTEM OFF**

HYDRAULIC PRESSURE ENGINE

Message: **HYD PRESS ENG 1, 2, 3, 4**

Engine Pump Sel . . . . **AFFECTED SYSTEM OFF**

Hydraulics:

HYDRAULIC PRESSURE SYSTEM

Message: **HYD PRESS SYS 1, 2, 3, 4**

Demand Pump Sel . . . . **AFFECTED SYSTEM ON**
Engine Pump Sw . . . . **AFFECTED SYSTEM OFF**

IF message HYD PRESS SYS...

...no longer displayed:
END.

...remains displayed:

Demand Pump Sel . . . . **AFFECTED SYSTEM OFF**

IF affected system is...

...system 1:

Autopilot C . . . . **OFF**

- Left outboard elevator is inoperative
- Inboard trailing edge flap hydraulic is inoperative
- Nose and body gear hydraulic actuation is inoperative
- Nose and body gear steering is inoperative
- System 1 alternate brake source is inoperative

...system 2:

Autopilot R . . . . **OFF**

- System 2 alternate brake source is inoperative
- Stabilizer trim rate is reduced
- Spoiler capability is reduced

...system 3:

Autopilot L . . . . **OFF**

- Stabilizer trim rate is reduced
- Spoiler capability is reduced

...system 4:

- Right outboard elevator is inoperative
- Outboard trailing edge flap hydraulic is inoperative
- Wing gear hydraulic actuation is inoperative
- Primary brake source and autobrakes are inoperative
- Spoiler capability is reduced

Landing Gear:

ANTISKID

Message: **ANTISKID**

- Brake effectiveness may be reduced
- Autobrake system is inoperative

AUTOBRAKES

Message: **AUTOBRAKES**

Autobrakes Sel .... **OFF, THEN AS DESIRED**

IF message AUTOBRAKES remains displayed:

Autobrakes Sel .... **OFF**

BRAKE TEMPERATURE

Message: **BRAKE TEMP**

Observe gear speed limits:

- In transit 270 kts / .82 M
- Extended 320 kts / .82 M

IF condition permits:

Gear Lever .... **DN**

- Inflight cooling time: Minimum 8 minutes
- On ground cooling time: Minimum 70 minutes

Landing Gear:

FIRE WHEEL WELL

Message: **FIRE WHEEL WELL**

> Observe gear speed limits:
> - In transit 270 kts / .82 M
> - Extended 320 kts / .82 M

Gear Lever .... **DN, LEAVE DOWN**
Next Suitable Airport .... **SELECT**

IF gear retraction is required to reach the next suitable airport and when 20 minutes passed after FIRE WHEEL WELL message is no longer displayed:

> Observe gear extent speed limit: 270 kts / .82 M

Gear Lever .... **UP**

GEAR DISAGREE

Message: **GEAR DISAGREE**

IF gear lever is...

...UP:
Observe gear extent limit speed: 270 kts / .82 M
END.

...DN and any gear not down:

Gear Lever .... **OFF**
Alternate Gear Extent Sw .... **AFFECTED GEAR ALTN**

IF gear indication...

...all down:

Gear Lever .... **DN**
END.

...any gear not down:

Gear Lever .... **DN**
Ground Proximity/Config Gear Override Sw .... **OVRD**

Miscellaneous:

DITCHING

NOTE: Final checklist is integrated

PREPARATION

Fuel Jettison	**AS REQUIRED**	
Crew Briefing	**PERFORM**	
ATC	**INFORM**	
Transponder	**AS REQUIRED**	
Passenger Signs	**ON**	
Landing Elevation	**SET**	
Loose Equipment	**STOW**	**B**
Survival Equipment	**PREPARE**	
Life Vest	**ON**	**B**

BEFORE IMPACT REVIEW

- At 150 ft: PA announcement "SAFETY POSITION"
- Maintain sinkrate 200-300 fpm
- If possible, plan to touch down on windward side and parallel to waves or swells
- To accomplish flare and touchdown, smoothly rotate to touchdown attitude of 10°-12°, maintaining airspeed and sinkrate with thrust.
- If two engines are inoperative maintain VMCA 167 kts or symmetrical thrust
- At touchdown reduce thrust to idle

AFTER IMPACT REVIEW

- Cut off all fuel control switches
- Pull and rotate all engine fire switches
- Initiate evacuation

BELOW 5 000 FT

Ground Proximity/Config Gear Override Sw	**OVRD**
Pack Control Sels	**ALL OFF**
Outflow Valve Manual Sws	**BOTH ON**
Outflow Valve Manual Control	**CLOSE**
Emergency Lights	**ON**

FINAL CHECKLIST

Gear Lever	**UP**
Flap Lever	**30**
Airspeed	**VREF30**
Touchdown Target Attitude	**10°-12°**